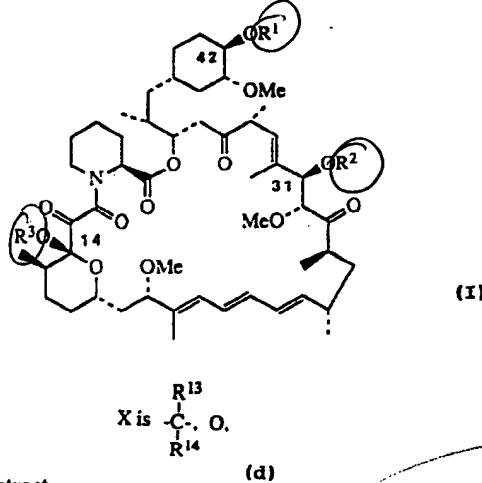


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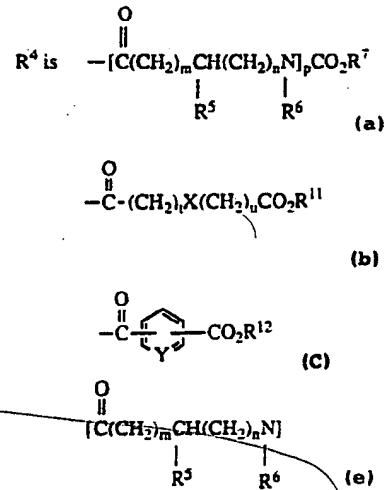
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(54) Title: CARBOXYLIC ACID ESTERS OF RAPAMYCIN



(57) Abstract

A compound of structure (I), wherein R¹, R², and R³ are each, independently, hydrogen, or R⁴; R⁴ is (a), (b), or (c); R⁵ is hydrogen, alkyl, aralkyl, -(CH₂)_qCO₂R⁸, -(CH₂)_qNR⁹CO₂R¹⁰, carbamylalkyl, aminoalkyl, hydroxyalkyl, guanylalkyl, mercaptoalkyl, alkylthioalkyl, indolylmethyl, hydroxyphehnylmethyl, imidazoylmethyl or phenyl which is optionally mono-, di-, or tri-substituted with a substituent selected from alkyl, alkoxy, hydroxy, cyano, halo, nitro, carbalkoxy, trifluoromethyl, amino, or a carboxylic acid; R⁶ and R⁹ are each, independently, hydrogen, alkyl, or aralkyl; R⁷, R⁸, and R¹⁰ are each, independently, alkyl, aralkyl, fluorenylmethyl, or phenyl which is optionally mono-, di-, or tri-substituted; R¹¹ and R¹² are each, independently, alkyl, aralkyl, or phenyl which is optionally mono-, di-, or tri-substituted; X is (d), O, or S; R¹³ and R¹⁴ are each, independently, hydrogen or alkyl; Y is CH or N; m is 0-4; n is 0-4; p is 1-2; q is 0-4; r is 0-4; t is 0-4; u is 0-4; wherein R⁵, R⁶, m, and n are independent in each of (e) subunits when p=2; or a pharmaceutically acceptable salt thereof, with the proviso that R¹, R², and R³ are not all hydrogen, further provided that R¹, R² and R³ are not all (a), and still further provided that t and u are not both 0 when X is O or S, which by virtue of its immuno-suppressive activity is useful in treating transplantation rejection, host vs. graft disease, autoimmune diseases, and diseases of inflammation, and by virtue of its antifungal activity is useful in treating fungal infections.



+ DESIGNATIONS OF "SU"

Any designation of "SU" has effect in the Russian Federation. It is not yet known whether any such designation has effect in other States of the former Soviet Union.

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CARBOXYLIC ACID ESTERS OF RAPAMYCIN

BACKGROUND OF THE INVENTION

This invention relates to novel esters of rapamycin and a method for using them
5 in the treatment of transplantation rejection, host vs. graft disease, autoimmune
diseases, diseases of inflammation, and fungal infections.

Rapamycin is a macrocyclic triene antibiotic produced by Streptomyces
10 hygroskopicus, which was found to have antifungal activity, particularly against
10 Candida albicans, both in vitro and in vivo [C. Vezina et al., J. Antibiot. 28, 721
(1975); S.N. Seghal et al., J. Antibiot. 28, 727 (1975); H. A. Baker et al., J. Antibiot.
31, 539 (1978); U.S. Patent 3,929,992; and U.S. Patent 3,993,749].

Rapamycin alone (U.S. Patent 4,885,171) or in combination with picibanil
(U.S. Patent 4,401,653) has been shown to have antitumor activity. R. Martel et al.
15 [Can. J. Physiol. Pharmacol. 55, 48 (1977)] disclosed that rapamycin is effective in
the experimental allergic encephalomyelitis model, a model for multiple sclerosis; in the
adjuvant arthritis model, a model for rheumatoid arthritis; and effectively inhibited the
formation of IgE-like antibodies.

The immunosuppressive effects of rapamycin have been disclosed in FASEB 3,
20 3411 (1989), rapamycin has been shown to be effective in inhibiting transplant
rejection (U.S. Patent Application Ser. No. 362,544 filed June 6, 1989). Cyclosporin
A and FK-506, other macrocyclic molecules, also have been shown to be effective as
immunosuppressive agents, therefore useful in preventing transplant rejection [FASEB
3, 3411 (1989); FASEB 3, 5256 (1989); and R. Y. Calne et al., Lancet 1183 (1978)].

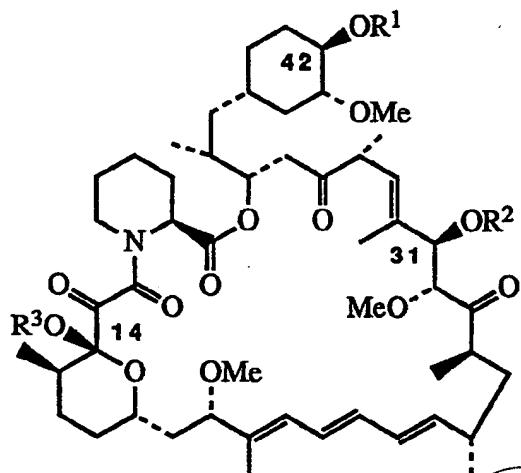
25 Mono- and diacylated derivatives of rapamycin (esterified at the 28 and 43
positions) have been shown to be useful as antifungal agents (U.S. Patent 4,316,885)
and used to make water soluble prodrugs of rapamycin (U.S. Patent 4,650,803).
Recently, the numbering convention for rapamycin has been changed; therefore
according to Chemical Abstracts nomenclature, the esters described above would be at
30 the 31- and 42- positions.

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DESCRIPTION OF THE INVENTION

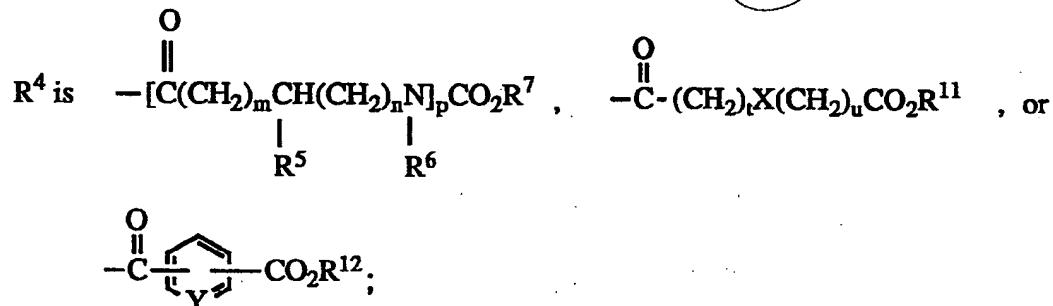
This invention provides derivatives of rapamycin which are useful as immunosuppressive, anti-inflammatory, and antifungal agents having the structure

5



wherein R¹, R², and R³ are each, independently, hydrogen, or R⁴;

10



15

R⁵ is hydrogen, alkyl of 1-6 carbon atoms, aralkyl of 7-10 carbon atoms, -(CH₂)_qCO₂R⁸, -(CH₂)_rNR⁹CO₂R¹⁰, carbamylalkyl of 2-3 carbon atoms, aminoalkyl of 1-4 carbon atoms, hydroxyalkyl of 1-4 carbon atoms, guanylalkyl of 2-4 carbon atoms, mercaptoalkyl of 1-4 carbon atoms, alkylthioalkyl of 2-6 carbon atoms, indolylmethyl, hydroxyphenylmethyl, imidazolylmethyl or phenyl which is optionally mono-, di-, or tri-substituted with a substituent selected from alkyl of 1-6 carbon atoms, alkoxy of 1-6 carbon atoms, hydroxy, cyano, halo, nitro, carbalkoxy of 2-7 carbon atoms, trifluoromethyl, amino, or a carboxylic acid;

20

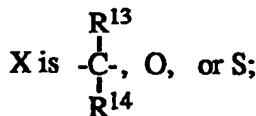
R⁶ and R⁹ are each, independently, hydrogen, alkyl of 1-6 carbon atoms, or aralkyl of 7-10 carbon atoms;

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R^7 , R^8 , and R^{10} are each, independently, alkyl of 1-6 carbon atoms, aralkyl of 7-10 carbon atoms, fluorenylmethyl, or phenyl which is optionally mono-, di-, or tri-substituted with a substituent selected from alkyl of 1-6 carbon atoms, alkoxy of 1-6 carbon atoms, hydroxy, cyano, halo, nitro, carbalkoxy of 2-7 carbon atoms, trifluoromethyl, amino, or a carboxylic acid;

5 R^{11} and R^{12} are each, independently, alkyl of 1-6 carbon atoms, aralkyl of 7-10 carbon atoms, or phenyl which is optionally mono-, di-, or tri-substituted with a substituent selected from alkyl of 1-6 carbon atoms, alkoxy of 1-6 carbon atoms, hydroxy, cyano, halo, nitro, carbalkoxy of 2-7 carbon atoms,

10 trifluoromethyl, amino, or a carboxylic acid;



R^{13} and R^{14} are each, independently, hydrogen or alkyl of 1-6 carbon atoms;

15 Y is CH or N;

 m is 0 - 4;

 n is 0 - 4;

 p is 1 - 2;

 q is 0 - 4;

20 r is 0 - 4;

 t is 0 - 4;

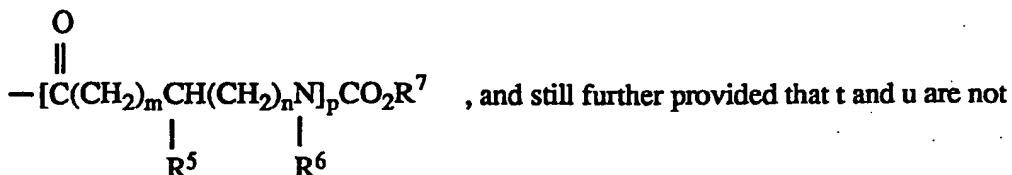
 u is 0 - 4;

$$\begin{array}{c} O \\ || \\ \text{wherein } R^5, R^6, m, \text{ and } n \text{ are independent in each of the } [C(CH_2)_m CH(CH_2)_n N] \\ | \qquad | \\ R^5 \qquad R^6 \end{array}$$

subunits when $p = 2$;

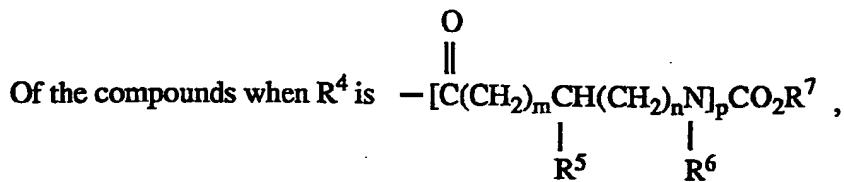
or a pharmaceutically acceptable salt thereof, with the proviso that R^1 , R^2 , and R^3 are

25 not all hydrogen, further provided that R^1 , R^2 , and R^3 are not all



both 0 when X is O or S.

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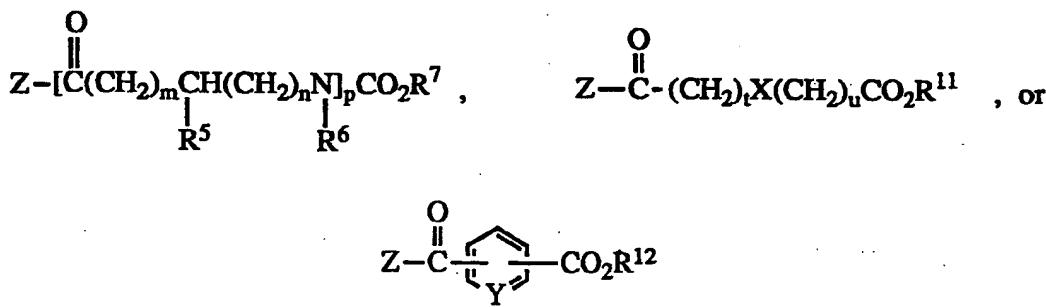


preferred members are those in which $m = 0$, $n = 0$, and $p = 1$; $m = 0$, $n = 0$, and $p = 2$; $n = 0$, and R^5 is $-(CH_2)_qCO_2R^8$; $m = 0$, $n = 0$, and R^5 is $-(CH_2)_pNR^9CO_2R^{10}$; and $m = 0$, $n = 0$, and R^5 is hydrogen. Preferred compounds also include those

5 members in which R^4 is $-\overset{\text{O}}{=} \text{C}-(\text{CH}_2)_t \text{X}(\text{CH}_2)_u \text{CO}_2 \text{R}^{11}$.

The pharmaceutically acceptable salts may be formed from inorganic cations such as sodium, potassium, and the like; mono-, di-, and trialkyl amines of 1-6 carbon atoms, per alkyl group and mono-, di-, and trihydroxyalkyl amines of 1-6 carbon atoms per alkyl group; and organic acids such as acetic, lactic, citric, tartaric, succinic, maleic, malonic, gluconic, and the like. Preferred basic salts are formed from sodium cations and tris(hydroxymethyl)methylamine.

The compounds of this invention can be prepared by acylating rapamycin with an acylating agent having the general structures



15 where Z is OH in the presence of a coupling reagent, such as dicyclohexylcarbodiimide. The compounds of this invention also can be prepared using an anhydride or a mixed anhydride of the above described carboxylic acid as the acylating species. Alternatively, the acylating species can be an acid halide, where Z can be Cl,
20 Br, or I. The acylating groups used to prepare the compounds of this invention are commercially available or can be prepared by methods that are disclosed in the literature.

Where it is desired to prepare acyl derivatives having two or three different R^4 groups then sequential acylation may be performed using appropriate acylating agents as defined above, if necessary isolating the desired product by appropriate purification

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techniques. In general the 42-position is acylated first and such a monoacylated product may be isolated prior to the second acylation and so forth. Appropriate protecting groups may be used to block any position where acylation is not required.

5 Immunosuppressive activity was evaluated in an in vitro standard pharmacological test procedure to measure lymphocyte proliferation (LAF) and in two in vivo standard pharmacological test procedures. The first in vivo procedure was a popliteal lymph node (PLN) test procedure which measured the effect of compounds of this invention on a mixed lymphocyte reaction and the second in vivo procedure evaluated the survival time of a pinch skin graft.

10 The comitogen-induced thymocyte proliferation procedure (LAF) was used as an in vitro measure of the immunosuppressive effects of representative compounds. Briefly, cells from the thymus of normal BALB/c mice are cultured for 72 hours with PHA and IL-1 and pulsed with tritiated thymidine during the last six hours. Cells are cultured with and without various concentrations of rapamycin, cyclosporin A, or test 15 compound. Cells are harvested and incorporated; radioactivity is determined. Inhibition of lymphoproliferation is assessed in percent change in counts per minute from non-drug treated controls. The results are expressed by the following ratio, or as the percent inhibition of lymphoproliferation of 1 μ M.

20 $\frac{^3\text{H-control thymus cells} - ^3\text{H-rapamycin-treated thymus cells}}{^3\text{H-control thymus cells} - ^3\text{H-test compound-treated cells}}$

A mixed lymphocyte reaction (MLR) occurs when lymphoid cells from genetically distinct animals are combined in tissue culture. Each stimulates the other to 25 undergo blast transformation which results in increased DNA synthesis that can be quantified by the incorporation of tritiated thymidine. Since stimulating a MLR is a function of disparity at Major Histocompatibility antigens, an in vivo popliteal lymph node (PLN) test procedure closely correlates to host vs. graft disease. Briefly, irradiated spleen cells from BALB/c donors are injected into the right hind foot pad of 30 recipient C3H mice. The drug is given daily, p.o. from Day 0 to Day 4. On Day 3 and Day 4, tritiated thymidine is given i.p., b.i.d. On Day 5, the hind popliteal lymph nodes are removed and dissolved, and radioactivity counted. The corresponding left PLN serves as the control for the PLN from the injected hind foot. Percent suppression is calculated using the non-drug treated animals as allogenic control. 35 Rapamycin at a dose of 6 mg/kg, p.o. gave 86% suppression, whereas cyclosporin A at the same dose gave 43% suppression. Results are expressed by the following ratio:

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³H-PLN cells control C3H mouse - ³H-PLN cells rapamycin-treated C3H mouse
³H-PLN cells control C3H mouse - ³H-PLN cells test compound-treated C3H mouse

5 The second *in vivo* test procedure is designed to determine the survival time of pinch skin graft from male DBA/2 donors transplanted to male BALB/c recipients. The method is adapted from Billingham R.E. and Medawar P.B., *J. Exp. Biol.* 28:385-402, (1951). Briefly, a pinch skin graft from the donor is grafted on the dorsum of the recipient as a homograft, and an autograft is used as control in the same region. The
10 recipients are treated with either varying concentrations of cyclosporin A as test control or the test compound, intraperitoneally. Untreated recipients serve as rejection control. The graft is monitored daily and observations are recorded until the graft becomes dry and forms a blackened scab. This is considered as the rejection day. The mean graft survival time (number of days \pm S.D.) of the drug treatment group is compared with
15 the control group.

20 The following table summarizes the results of representative compounds of this invention in these three standard test procedures.

TABLE 1

	<u>Compound</u>	<u>LAF*</u> (ratio)	<u>PLN*</u> (ratio)	<u>Skin Graft</u> (days \pm SD)
	Example 1	1.8	0.61	12.0 \pm 1.6
	Example 2	0.33	0.62	11.5 \pm 0.6
25	Example 3	0.20	+	9.0 \pm 0.9
	Example 4	4.9	0.18	12.3 \pm 0.5
	Example 5	0.006	+	8.8 \pm 0.9
	Example 6	5.4	0.33	11.5 \pm 3.5
	Example 7	3% at 1 μ M**	+	7.7 \pm 1.5
30	Example 8	0.03	0.41	+
	Example 9	0.96	1.34	10.3 \pm 0.8
	Example 10	2.0	0.96 ⁺⁺	12.7 \pm 1.2
	Example 11	0.004	+	10.5 \pm 1.3
	Example 12	19.8	-2.87	12.0 \pm 2.0
35	Example 13	22% at 1 μ M**	+	7.0 \pm 0.6
	Example 14	0.37	+	8.2 \pm 1.2
	Example 15	0.9	0.69	10.7 \pm 1.2

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TABLE 1 (Continued)

	<u>Compound</u>	<u>LAF*</u> (ratio)	<u>PLN*</u> (ratio)	<u>Skin Graft</u> (days + SD)
5	Example 16	3.27	1.04##	12.7 ± 0.9
	Example 17	0.56	1.68###	10.2 ± 1.7
	Example 18	0.02	1.11##	8.0 ± 1.7
	Example 19	0.01	0.48	8.0 ± 0.9
	Example 20	0.97	0.70	9.3 ± 1.6
10	Example 21	0.22	-1.93	12.0 ± 1.7
	Example 22	0.22	0.41	10.2 ± 1.2
	Example 23	0.18	0.39	10.8 ± 0.8
	Example 24	0.00	0.09	7.8 ± 1.7
	Rapamycin	1.0	1.0	12.0 ± 1.7

15

* Calculation of ratios was described supra.** Result expressed as percent inhibition of lymphoproliferation at 1 μ M.

+ Not evaluated

++ Results obtained using cremophore/ethanol as a vechicle for administration.

20 Ratios of 0.33 and 1.07 were also obtained using carboxymethyl cellulose as a vehicle for administration.

Results obtained using cremophore/ethanol as a vechicle for administration.

Ratios of 0.20 and 1.08 also were obtained using carboxymethyl cellulose as a vehicle for administration.

25 ### A ratio of 0.42 also was obtained for this compound.

30 The results of these standard pharmacological test procedures demonstrate immunosuppressive activity both in vitro and in vivo for the compounds of this invention. Positive ratios in the LAF and PLN test procedures indicate suppression of T cell proliferation. As a transplanted pinch skin grafts are typically rejected within 6-7 days without the use of an immunosuppressive agent, the increased survival time of the skin graft when treated with the compounds of this invention further demonstrates their utility as immunosuppressive agents. While it appears that the compound disclosed by

35 Examples 12 and 21 may cause T cell proliferation in the PLN test procedure, it is believed a negative ratio in this test procedure coupled with an increased survival time observed in the skin graft test procedure indicates a proliferation of $T_{suppressor}$ cells,

which are implicated in suppressing the immune response. (see, I. Roitt et al. *Immunology*, C.V.Moseby Co. 1989, p 12.8-12.11).

Antifungal activity of the compounds of this invention was measured against 5 strains of Candida albicans using a plate test procedure for measurement of inhibition. The following represents the typical procedure used. Compound to be tested was placed on sterile dried 1/4" plate disks, and allowed to dry. Agar plates were seeded with fungi and allowed to solidify. The impregnated disks were placed on the seeded Agar surface and incubated for the time required for the particular culture. Results are expressed in MIC (μ g/ml) to inhibit growth. The results of this test procedure showed that the compounds of this invention have antifungal activity; however, it was surprising that the compounds of this invention were less active than the parent compound, rapamycin.

15

Table 2*

Strain of *Candida albicans*

Compound	ATCC 10231	ATCC 38246	ATCC 38247	ATCC 38248	3669
Example 1	> 0.4	> 0.4	> 0.4	>0.4	>0.4
Example 2	0.1	0.2	0.2	0.2	0.1
Example 3	0.4	> 0.4	> 0.4	>0.4	0.4
Example 4	0.1	0.4	0.1	0.1	0.2
Example 5	> 0.4	> 0.4	> 0.4	>0.4	>0.4
Example 6	0.1	> 0.4	0.2	0.4	>0.4
Example 7	+	+	+	+	+
Example 8	> 0.4	> 0.4	> 0.4	>0.4	>0.4
Example 9	0.4	> 0.4	0.4	>0.4	>0.4
Example 10	0.2	> 0.4	0.2	0.4	0.4
Example 11	> 0.4	> 0.4	> 0.4	>0.4	>0.4
Example 12	0.2	> 0.4	0.1	0.2	0.4
Example 13	> 0.4	> 0.4	> 0.4	>0.4	>0.4
Example 14	> 0.4	> 0.4	> 0.4	>0.4	>0.4
Example 15	> 0.4	0.4	> 0.4	0.4	0.4
Example 16	0.2	0.1	0.4	0.1	0.1
Example 17	> 0.4	0.2	> 0.4	0.2	0.4
Example 18	0.4	> 0.4	> 0.4	>0.4	>0.4
Example 19	0.4	> 0.4	0.4	>0.4	>0.4

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Table 2* (Continued)
Strain of *Candida albicans*

<u>Compound</u>	<u>ATCC 10231</u>	<u>ATCC 38246</u>	<u>ATCC 38247</u>	<u>ATCC 38248</u>	<u>3669</u>
5	Example 20	0.1	0.4	0.1	0.2
	Example 21	0.4	> 0.4	0.4	> 0.4
	Example 22	0.2	> 0.4	0.2	> 0.4
	Example 23	0.1	> 0.4	0.2	> 0.4
	Example 24	> 0.4	> 0.4	> 0.4	> 0.4
	Rapamycin	0.003	0.025	0.003	0.006

10

* expressed as MIC (μg/ml)

15 + not evaluated

Based on the results of these standard pharmacological test procedures, the 15 compounds are useful in the treatment of transplantation rejection such as, heart, kidney, liver, bone marrow, and skin transplants; autoimmune diseases such as, lupus, rheumatoid arthritis, diabetes mellitus, myasthenia gravis, and multiple sclerosis; and diseases of inflammation such as, psoriasis, dermatitis, eczema, seborrhea, inflammatory bowel disease; and fungal infections.

20 The compounds may be administered neat or with a pharmaceutical carrier to a mammal in need thereof. The pharmaceutical carrier may be solid or liquid.

25 A solid carrier can include one or more substances which may also act as flavoring agents, lubricants, solubilizers, suspending agents, fillers, glidants, compression aids, binders or tablet-disintegrating agents; it can also be an encapsulating material. In powders, the carrier is a finely divided solid which is in admixture with the finely divided active ingredient. In tablets, the active ingredient is mixed with a carrier having the necessary compression properties in suitable proportions and compacted in the shape and size desired. The powders and tablets preferably contain up to 99% of the active ingredient. Suitable solid carriers include, for example, calcium phosphate, 30 magnesium stearate, talc, sugars, lactose, dextrin, starch, gelatin, cellulose, methyl cellulose, sodium carboxymethyl cellulose, polyvinylpyrrolidone, low melting waxes and ion exchange resins.

35 Liquid carriers are used in preparing solutions, suspensions, emulsions, syrups, elixirs and pressurized compositions. The active ingredient can be dissolved or suspended in a pharmaceutically acceptable liquid carrier such as water, an organic solvent, a mixture of both or pharmaceutically acceptable oils or fats. The liquid carrier

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can contain other suitable pharmaceutical additives such as solubilizers, emulsifiers, buffers, preservatives, sweeteners, flavoring agents, suspending agents, thickening agents, colors, viscosity regulators, stabilizers or osmo-regulators. Suitable examples of liquid carriers for oral and parenteral administration include water (partially 5 containing additives as above, e.g. cellulose derivatives, preferably sodium carboxymethyl cellulose solution), alcohols (including monohydric alcohols and polyhydric alcohols, e.g. glycols) and their derivatives, and oils (e.g. fractionated coconut oil and arachis oil). For parenteral administration, the carrier can also be an oily ester such as ethyl oleate and isopropyl myristate. Sterile liquid carriers are useful 10 in sterile liquid form compositions for parenteral administration. The liquid carrier for pressurized compositions can be halogenated hydrocarbon or other pharmaceutically acceptable propellant.

Liquid pharmaceutical compositions which are sterile solutions or suspensions can be utilized by, for example, intramuscular, intraperitoneal or subcutaneous 15 injection. Sterile solutions can also be administered intravenously. The compound can also be administered orally either in liquid or solid composition form.

Preferably, the pharmaceutical composition is in unit dosage form, e.g. as tablets or capsules. In such form, the composition is sub-divided in unit dose containing appropriate quantities of the active ingredient; the unit dosage forms can be 20 packaged compositions, for example, packeted powders, vials, ampoules, prefilled syringes or sachets containing liquids. The unit dosage form can be, for example, a capsule or tablet itself, or it can be the appropriate number of any such compositions in package form. The dosage to be used in the treatment must be subjectively determined by the attending physician.

25 In addition, the compounds of this invention may be employed as a solution, cream, or lotion by formulation with pharmaceutically acceptable vehicles containing 0.1- 5 percent, preferably 2%, of active compound which may be administered to a fungally affected area.

30

The following examples illustrate the preparation of representative compounds of this invention.

- 11 -

Example 1

Rapamycin-42-ester with N-[(1,1-dimethylethoxy)carbonyl]-glycylglycine

5 Under anhydrous conditions, a solution of rapamycin (3 g, 3.28 mmole) and N-[(1,1-dimethylethoxy)carbonyl]-glycylglycine (3.04 g, 13.1 mmole) in 40 mL of anhydrous dichloromethane was treated with dicyclohexylcarbodiimide (1.35 g, 6.56 mmole) followed by 4-dimethylaminopyridine (0.8 g, 6.56 mmole). After stirring at ambient temperature for 48 hours, the precipitated solid was collected and washed with 10 dichloromethane. The combined filtrates were absorbed directly onto silica gel Merck 60 by adding the gel and evaporation to dryness. Flash chromatography of the preabsorbed material (using a gradient elution with ethylacetate-toluene from 2:1 to 1:0 v/v) afforded 1.05 g (28.3 %) of the title compound isolated as a three quarter toluene solvate, along with the 31,42-diester of Example 2. HPLC analysis showed that the 15 monoester is a 8.3:1 mixture of two conformers.

1H NMR (CDCl₃, 400 MHz): δ 1.46 (m, 9H, COOBu^t), 1.654 (s, 3H, CH₃C=C), 1.751 (s, 3H, CH₃C=C), 3.14 (s, 3H, CH₃O), 3.33 (s, 3H, CH₃O), 3.36 (s, 3H, CH₃O), 4.18 (d, 1H, CHO), 4.75 (m, 1H, 42-CHO), 4.79 (s, 1H, OH); High Res. MS (neg. ion FAB) Calcd for C₆₀H₉₃N₃O₁₇: 1127.6504, measured mass 1127.6474.

20 Anal. Calcd for C₆₀H₉₃N₃O₁₇ · 0.75 PhCH₃: C, 65.45; H, 8.33; N, 3.51
Found: C, 65.23; H, 8.32; N, 3.86

25

The following representative compounds can be prepared from rapamycin and the appropriate terminally-N-substituted amino acid by employing the method used to prepare the title compound in Example 1.

30 Rapamycin-42-ester with N-[(fluorenylmethoxy)carbonyl]-alanylserine
Rapamycin-42-ester with N-[(fluorenylmethoxy)carbonyl]-glycylglycine
Rapamycin-42-ester with N-[(ethoxy)carbonyl]-arginylmethionine
Rapamycin-42-ester with N-[(4'-chlorophenoxy)carbonyl]-histidylarginine
Rapamycin-42-ester with N-[(phenoxy)carbonyl]-tryptophanylleucine
35 Rapamycin-42-ester with N-[(phenylmethoxy)carbonyl])-N-methylglycyl-N-ethylalanine

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Rapamycin-42-ester with N-[(phenylmethoxy)carbonyl]-N-methyl- β -alanylphenylalanine

Rapamycin-42-ester with N-[(1,1-dimethylethoxy)carbonyl]-cysteinylglycine

5

Example 2

Rapamycin-31,42-diester with N-[(1,1-dimethylethoxy)carbonyl]-glycylglycine

10 The title compound (1.85 g, 42%) was separated from the 42-monoester as described in Example 1 and isolated as a three quarter toluene solvate. HPLC analysis showed that the diester is a 8.1:1 mixture of conformers.

15 ^1H NMR (CDCl₃, 400 MHz): δ 1.452 (m, 18H, COOBu^t), 1.6612 (s, 3H, CH₃C=C), 1.7815 (s, 3H, CH₃C=C), 3.14 (s, 3H, OCH₃), 3.34 (s, 3H, OCH₃), 3.35 (s, 3H, OCH₃), 4.52 (s, 1H, OH), 4.79 (m, 1H, 42-CHO); High Res. MS (neg. ion FAB): Calcd for C₆₉H₁₀₇N₅O₂₁ 1341.7458, measured mass: 1341.7463.

Anal. Calcd for C₆₉H₁₀₇N₅O₂₁ · 0.75 PhCH₃: C, 63.17; H, 8.06; N, 4.96
Found: C, 62.83; H, 8.09; N, 5.00

20

The following representative compounds can be prepared from rapamycin and the appropriate terminally-N-substituted amino acid by employing the method used to prepare the title compound in Example 2.

25 Rapamycin-31,42-diester with N-[(fluorenylmethoxy)carbonyl]-alanylserine

Rapamycin-31,42-diester with N-[(fluorenylmethoxy)carbonyl]-glycylglycine

Rapamycin-31,42-diester with N-[(ethoxy)carbonyl]-arginylmethionine

Rapamycin-31,42-diester with N-[(4'-chlorophenoxy)carbonyl]-histidylarginine

Rapamycin-31,42-diester with N-[(phenoxy)carbonyl]-tryptophanylleucine

30 Rapamycin-31,42-diester with N-[(phenylmethoxy)carbonyl]-N-methylglycyl-N-ethyl-alanine

Rapamycin-31,42-diester with N-[(phenylmethoxy)carbonyl]-N-methyl- β -alanylphenyl-alanine

Rapamycin-31,42-diester with N-[(1,1-dimethylethoxy)carbonyl]-cysteinylglycine

35

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Example 3

Rapamycin-31,42-diester with N-[(1,1-dimethylethoxy)carbonyl]-N-methylglycine

5 Under anhydrous conditions, an ice cold solution of rapamycin (2 g, 2.18 mmole) and N^α-Boc sarcosine (1.65 g, 8.75 mmole) in 20 ml of anhydrous dichloromethane was treated with dicyclohexylcarbodiimide (1.8 g, 8.7 mmole) followed by 4-dimethylaminopyridine (1 g, 8.7 mmole). After stirring overnight at ambient temperature, the precipitated solid was collected and washed with dichloromethane. The combined filtrates were evaporated to dryness to give an amorphous amber solid (3 g). The crude product was purified by flash chromatography (on silica Merck 60, elution with hexane-ethylacetate 1:1, v/v) to provide the title compound (0.75 g, 27.4%) along with the 42-monoester of Example 4. HPLC analysis showed that the diester is a 19.8:1 mixture of two conformers. The multiplicity of the NMR peaks suggests the presence of amide rotamers.

¹H NMR (CDCl_3 , 400 MHz): δ 1.411, 1.438, 1.448 and 1.474 (m, 18 H, COOBu^t), 2.91 (m, 6H, NCH_3), 3.14 (s, 3H, CH_3O), 3.34 (s, 3H, CH_3O), 3.37 (s, 3H, CH_3O), 4.73 (broad, 1H, 42-CHO), 4.82 (2s, 1H, OH); High Res. MS (neg. ion FAB): Calcd. for $\text{C}_{67}\text{H}_{105}\text{N}_3\text{O}_{19}$ 1255.7342, measured mass 1255.7289.

The following representative compounds can be prepared from rapamycin and the appropriate terminally-N-substituted amino acid by employing the method used to 25 prepare the title compound in Example 3.

Rapamycin-31,42-diester with N-[(ethoxy)carbonyl]-tyrosine

Rapamycin-31,42-diester with N-[(fluorenylmethoxy)carbonyl]-phenylalanine

Rapamycin-31,42-diester with N-[$(3',4',5'$ -trihydroxyphenoxy)carbonyl]-isoleucine

30 Rapamycin-31,42-diester with N-[(1,1-dimethylethoxy)carbonyl]-glutamine

Rapamycin-31,42-diester with N-[(phenoxy)carbonyl]-N-methylalanine

Rapamycin-31,42-diester with N-[propyloxy]carbonyl]-4-aminobutyric acid

Ranamycin-31,42-diester with N-[*(phenylmethoxy)carbonyl*]-7-aminoheptanoic acid

Ranamycin-31,42-diester with N-[(fluoren-9-yl)methoxy]carbonyl-serine

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Example 4

Rapamycin-42-ester with N-[(1,1-dimethylethoxy)carbonyl]-N-methylglycine

5 Under anhydrous conditions, an ice cold solution of rapamycin (0.95 g, 1.02 mmole) and N^{α} -Boc sarcosine (0.21 g, 1.1 mmole) in 20 mL of anhydrous dichloromethane was treated with dicyclohexylcarbodiimide 0.21 g, 1 mmole) followed by 4-dimethylaminopyridine (0.12 g, 1 mmole). After stirring for 4 hours at ambient temperature, the precipitated solid was collected and washed with dichloromethane. The
10 combined filtrates were concentrated *in vacuo* to give an amorphous amber solid. Flash chromatography of the crude product (on silica Merck 60, elution with hexane-ethylacetate 1:1 v/v to remove the diester of Example 3, followed by chloroform-ethylacetate-methanol 75:25:1 v/v) provided partially purified title compound (0.38 g, 35%). Pure product was obtained by preparative HPLC (Waters Prep 500, silica gel,
15 chloroform-ethylacetate-methanol 75:25:1 v/v, flow rate 250 mL/min). HPLC analysis showed that the ester is a 6.6:1 mixture of two conformers. The multiplicity of NMR peaks suggests the presence of amide rotamers.

20 1 H NMR (CDCl₃, 400 MHz): δ 1.42-1.46 (ds, 9H, COOBu^t), 2.91 (ds, 3H, NCH₃), 1.644 (s, 3H, CH₃C=C), 1.738 (s, 3H, CH₃C=C), 3.12 (s, 3H, CH₃O),
3.32 (s, 3H, CH₃O), 3.35 (s, 3H, CH₃O), 4.18 (d, 1H, CHO), 4.71 (broad, 1H,
42-CHO), 4.78 (broad s, 1H, OH); High Res. MS (neg. ion FAB): Calcd for C₅₉H₉₂N₂O₁₆ 1084.6446, measured mass 1084.6503.

Anal. Calcd for C₅₉H₉₂N₂O₁₆: C, 65.29; H, 8.54; N, 2.58

25 Found: C, 65.25; H, 8.52; N, 2.42

25

The following representative compounds can be prepared from rapamycin and the appropriate terminally-N-substituted amino acid by employing the method used to prepare the title compound in Example 4.

30 Rapamycin-42-ester with N-[(ethoxy)carbonyl]-tyrosine
Rapamycin-42-ester with N-[(fluorenylmethoxy)carbonyl]-phenylalanine
Rapamycin-42-ester with N-[(3',4',5'-trihydroxyphenoxy)carbonyl]-isoleucine
Rapamycin-42-ester with N-[(1,1-dimethylethoxy)carbonyl]-glutamine
Rapamycin-42-ester with N-[(phenoxy)carbonyl]-N-methylalanine
35 Rapamycin-42-ester with N-[(propyloxy)carbonyl]-4-aminobutyric acid
Rapamycin-42-ester with N-[(phenylmethoxy)carbonyl]-7-aminoheptanoic acid

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Rapamycin-31,42-diester with N-[(fluorenethylmethoxy)carbonyl]serine

Example 5

5 Rapamycin-31,42-diester with 5-(1,1-dimethylethoxy)-2-[(1,1-dimethylethoxy)-carbonyllamino]-5-oxopentanoic acid

Under anhydrous conditions, an ice cold solution of rapamycin (4 g, 4.37 mmole) and L-glutamic acid Na^+ -Boc- γ -tert-butylester (4.9 g, 16.1 mmole) in 40 mL of dry dichloromethane was treated with dicyclohexylcarbodiimide (1.8 g, 8.7 mmole) followed by 4-dimethylaminopyridine (1 g, 8.7 mmole). After stirring overnight at room temperature, the precipitated solid was collected and washed with dichloromethane. The combined filtrates were concentrated *in vacuo* to provide 11 g of an amorphous amber solid. The crude product was purified by flash chromatography (on silica Merck 60, gradient elution with hexane-ethylacetate from 2:1 to 1:1, v/v) to yield 4.52 g (69.6%) of the title compound along with the 42-monoester of Example 6. HPLC analysis showed that the diester consists of a 6.6:1 mixture of two conformers.

¹H NMR (CDCl₃, 400 MHz): δ 1.42 (m, 36 H, COOBu^t), 1.646 (s, 3H, CH₃C=C), 1.701 (s, 3H, CH₃C=C), 3.13 (s, 3H, CH₃O), 3.34 (s, 3H, CH₃O), 3.36 (s, 3H, CH₃O), 4.735 (m, 2H, OH+42-CH-O); High Res. MS (neg. ion FAB): calc. for C₇₉H₁₂₅N₃O₂₃ 1483.8715, measured mass 1483.8714.

Anal. Calcd for C₇₉H₁₂₅N₃O₂₃: C, 63.90; H, 8.49; N, 2.83

Found: C, 63.63; H, 8.41; N, 2.44

25

The following representative compounds can be prepared from rapamycin and the appropriately terminally-N-substituted amino diacid monoester by employing the method used to prepare the title compound in Example 5.

30 Rapamycin-31,42-diester with 6-(phenylmethoxy)-2-[[fluorenylmethoxy]carbonyl]-amino]-6-oxohexanoic acid

Rapamycin-31,42-diester with 6-(4'-methylphenoxy)-3-[(phenylmethoxy)carbonyl]-amino-6-oxohexanoic acid

35 Rapamycin-31,42-diester with 6-(ethoxy)-4-[[[phenoxy]carbonyl]amino]-6-oxo-
hexanoic acid

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Rapamycin-31,42-diester with 6-(methoxy)-5-[(ethoxy)carbonyl]amino]-6-oxo-hexanoic acid

Rapamycin-31,42-diester with 4-(phenoxy)-2-[N-[(1,1-dimethylethoxy)carbonyl]-N-methylamino]-4-oxobutanoic acid

5 Rapamycin-31,42-diester with 4-(phenylmethoxy)-3-[N-[(methoxy)carbonyl]-N-methylamino]-4-oxobutanoic acid

Example 6

10

Rapamycin-42-ester with 5-(1,1-dimethylethoxy)-2-[(1,1-dimethylethoxy)-carbonyl]amino]-5-oxopentanoic acid

15 The title compound (1.14 g, 20.6%) was separated from the 31,42-diester as described in Example 5 and isolated as the quarter hydrate/mono-ethyl acetate solvate. HPLC analysis showed that the monoester is a 11.5:1 mixture of two conformers.

16 ¹H NMR (CDCl₃, 400 MHz): δ 1.425 (m, 18H, COOBu^t), 1.643 (s, 3H, CH₃C=C), 1.737 (s, 3H, CH₃C=C), 3.13 (s, 3H, CH₃O), 3.32 (s, 3H, CH₃O), 3.36 (s, 3H, CH₃O), 4.17 (d, 1H, CHOH), 4.71 (M, 1H, 42-CHO), 4.785 (s, 1H, OH); High Resolution MS (neg. ion FAB): Calc. for C₆₅H₁₀₂N₂O₁₈ 1198.7127, measured mass 1198.7077.

20 Anal. Calcd for C₆₅H₁₀₂N₂O₁₈ · CH₃COOEt · 0.25 H₂O:
C, 64.13, H, 8.60; N, 2.17
Found: C, 64.18; H, 8.52; N, 2.01

25 The following representative compounds can be prepared from rapamycin and the appropriately terminally-N-substituted amino diacid monoester by employing the method used to prepare the title compound in Example 6.

30 Rapamycin-42-ester with 6-(phenylmethoxy)-2-[[fluorenylmethoxy]carbonyl]-amino]-6-oxohexanoic acid

Rapamycin-42-ester with 6-(4'-methylphenoxy)-3-[[phenylmethoxy]carbonyl]-amino-6-oxohexanoic acid

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Rapamycin-42-ester with 6-(ethoxy)-4-[[[phenoxy]carbonyl]amino]-6-oxo- hexanoic acid

Rapamycin-42-ester with 6-(methoxy)-5-[[[ethoxy]carbonyl]amino]-6-oxo- hexanoic acid

5 Rapamycin-42-ester with 4-(phenoxy)-2-[N-[(1,1-dimethylethoxy)carbonyl]-N-methylamino]-4-oxobutanoic acid

Rapamycin-42-ester with 4-(phenylmethoxy)-3-[N-[(methoxy)carbonyl]-N-methylamino]-4-oxobutanoic acid

10 **Example 7**

Rapamycin-31,42-diester with 2-[[1,1-dimethylethoxy]carbonyllamino]-4-oxo-4-(phenylmethoxy) butanoic acid

15 Under anhydrous conditions, 295mg (1.21mmol) of 2,4,6 trichlorobenzoyl chloride was added to a solution of 391mg(1.21mmol) of N^α-Boc-L-aspartic acid-β-benzyl ester and 170μL (1.21mmol) of Et₃N in 1 mL of THF at room temperature. After stirring for 30 minutes, 500 mg (0.55mmol) of rapamycin and 295 mg (2.42 mmol) of dimethylaminopyridine was added and the reaction was left to stir overnight.

20 The reaction mixture was then filtered and the filtrate concentrated *in vacuo*. Pure product (200 mg, 25%) was obtained by preparative HPLC (5 cm column, 40 % ethyl acetate-hexane). The product was isolated as the heptahydrate.

1H NMR (CDCl₃, 400 MHz) δ 7.347 (s, 10 H, Ar), 6.223, 5.126 (s, 4 H, CH₂Ph), 25 4.698 (m, 1 H, CH-CO₂), 4.587 (m, 2 H, NH), 3.353 (s, 3 H, CH₃O), 3.337 (s, 3 H, CH₃O), 3.301 (s, 3 H, CH₃O), 2.775 (m, 4 H, CH₂CO₂); IR (KBr) 3420 (OH), 2935 (CH), 2920 (CH), 1730 (C=O), 1650, 1500, 1455, 1370, 1170 cm⁻¹; MS (neg. ion FAB) 1523 (M⁻), 1433, 297, 248, 205, 148, 44, 25 (100).

Anal. Calcd for C₈₃H₁₁₇N₃O₂₃·7H₂O C, 60.40; H, 7.09; N, 2.54

30 Found: C, 60.54; H, 7.28; N, 2.56

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Example 8

Rapamycin-31,42-dieste with 3-[(1,1-dimethylethoxy)carbonyl]amino]-4-oxo-4-(phenylmethoxy) butanoic acid

5

Under anhydrous conditions, 532 mg (2.18 mmol) of 2,4,6 trichlorobenzoyl chloride in 1 mL THF was added to a solution of 704 mg (2.18 mmol) of $\text{N}^{\alpha}\text{-Boc-L-aspartic acid-}\alpha\text{-benzyl ester}$ and 303 μL (2.18 mmol) of Et_3N in 5 mL of THF at room temperature. After stirring for 20 minutes, the reaction mixture was filtered over sintered glass, and the precipitate was washed with THF. The filtrate was concentrated *in vacuo* to give a thick oil. The oil was dissolved in 5 mL of benzene and 1.00 g (1.09 mmol) of rapamycin and 532 mg (4.36 mmol) of dimethylaminopyridine in 1 mL of benzene was added dropwise. The reaction was stirred for 2 hr, poured into ethyl acetate, and washed consecutively with 0.5 N HCl and brine. The solution was dried over sodium sulfate, decanted, concentrated *in vacuo* to give a white foamy solid, which was purified via flash chromatography on a 60 mm x 100 mm silica column (20-40 % ethyl acetate/hexane as eluant) to give 532 mg (33 %) of the title compound which was isolated as the hydrate.

20 ^1H NMR (CDCl_3 , 400 MHz) δ 7.362 (s, 10 H, Ar), 5.193 (s, 4 H, CH_2Ph), 4.596 (m, 1 H, CH-CO_2), 4.586 (m, 2 H, NH), 3.336 (s, 3 H, CH_3O), 3.306 (s, 3 H, CH_3O), 3.145 (s, 3 H, CH_3O); IR (KBr) 3410 (OH), 2950 (CH), 2920 (CH), 1735 (C=O), 1710 (C=O), 1640, 1490, 1445, 1350, 1150 cm^{-1} ; MS (neg. ion FAB) 1524 (M^-), 1434, 297, 248, 232, 214, 205, 167, 148, 42 (100), 26.

25 Anal. Calcd for $\text{C}_{83}\text{H}_{117}\text{N}_3\text{O}_{23} \cdot \text{H}_2\text{O}$: C, 65.38; H, 7.73; N, 2.76
Found: C, 64.85; H, 7.67; N, 2.56

Example 9

30 Rapamycin-42-ester with 3-[(1,1-dimethylethoxy)carbonyl]amino]-4-oxo-4-(phenylmethoxy) butanoic acid

35 The title compound (374 mg, 23%) was prepared by the method described in the previous Example and separated from the compound described in the previous Example by flash chromatography (20-40% ethyl acetate/hexane as the eluant) and isolated as the sesquihydrate.

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¹H NMR (CDCl₃, 400 MHz) δ 7.356 (s, 5 H, Ar), 5.185 (s, 2 H, CH₂Ph), 4.635 (m, 1 H, CH-CO₂), 4.582 (m, 1 H, NH), 3.330 (s, 6 H, CH₃O), 3.135 (s, 3 H, CH₃O); IR (KBr) 3410 (OH), 2950 (CH), 2920 (CH), 1735 (C=O), 1710 (C=O), 1640, 1490, 1445, 1350, 1150 cm⁻¹; MS (neg. ion FAB) 1218 (M⁻), 1127, 590, 168, 542, 25, 17 (100).

Anal. Calcd for $C_{67}H_{98}N_2O_{18} \cdot 1.5 H_2O$: C, 63.64; H, 8.21; N, 2.22
Found: C, 63.64; H, 7.51; N, 2.13

Example 10

10 Rapamycin-42-ester with 5-(1,1-dimethoxy)-4-[(1,1-dimethylethoxy)carbonyl]amino]-5-oxopentanoic acid

Under anhydrous conditions, an ice cold solution of rapamycin (4 g, 4.37 mmole) and L-glutamic acid N^α-Boc- α -tert-butylester (4.9 g, 16.1 mmole) in 40 mL of anhydrous dichloromethane was treated with dicyclohexylcarbodiimide (1.8 g, 8.7 mmole) followed by 4-dimethylamino pyridine (1 g, 8.7 mmole). After stirring overnight at ambient temperature, the precipitated solid was collected and washed with dichloromethane. The combined filtrates were concentrated *in vacuo* to give 9 g of an amorphous amber solid. The crude product was purified by flash chromatography (on silica Merck 60, gradient elution with hexane-ethylacetate from 2:1 to 3:2, v/v) to provide 1.35 g (25.7%) of the title compound along with the 31,42-diester of Example 11. HPLC analysis showed that the monoester is a 7.5 :1 mixture of two conformers.

25 ¹H NMR (CDCl₃, 400 MHz): δ 1.43 (s, 9H, COOBu^t) and 1.46 (s, 9H, COOBu^t), 1.65 (s, 3H, CH₃C=C), 1.75 (s, 3H, CH₃C=C), 3.14 (s, 3H, CH₃O), 3.34 (s, 3H, CH₃O), 3.38 (s, 3H, CH₃O), 4.18 (d, 1H, CH-OH), 4.65 (m, 1H, 42-
 30 CHO), 4.80 (s, 1H, OH);
 High Res. MS (neg. ion FAB): Calc. for C₆₅H₁₀₂N₂O₁₈: 1198.7126, measured mass 1198.7135.

Anal. Calcd for $C_{65}H_{102}N_2O_{18}$: C, 65.09; H, 8.57; N, 2.34
 Found C, 65.04; H, 8.33; N, 2.64

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Example 11

Rapamycin-31,42-diester with 5-(1,1-dimethylethoxy)-4-[[(1,1-dimethylethoxy)-carbonyl]-aminol-5-oxopentanoic acid

5

The title compound was prepared (0.83 g, 12.8%) along with the 42-monoester as described in Example 10. HPLC analysis showed that the diester is a 7.7:1 mixture of two conformers.

10

¹H NMR (CDCl₃, 400 MHz): δ 1.43 (s, 18H, COOBu^t), 1.46 (s, 18H, COOBu^t), 1.659 (s, 3H, CH₃C=C), 1.759 (s, 3H, CH₃C=C), 3.14 (s, 3H, CH₃O), 3.34 (s, 3H, CH₃O), 3.38 (s, 3H, CH₃O), 4.66 (m, 1H, 42-CHO), 4.72 (s, 1H, OH); High Res. MS (neg. ion FAB): Calcd for C₇₉H₁₂₅N₃O₂₃: 1483.8704, measured mass 1483.8636.

15

Anal. Calcd for C₇₉H₁₂₅N₃O₂₃: C, 63.90; H, 8.49; N, 2.83

Found: C, 63.68; H, 8.60; N, 3.20

20

Example 12

Rapamycin-42-ester with N^α, N^ε-bis[(1,1-dimethylethoxy)carbonyl]-L-lysine

25

Under anhydrous conditions, a solution of rapamycin (3 g, 3.28 mmole) and N^α, N^ε-bis-Boc-L-lysine (4.5 g, 13 mmole) in 40 mL of anhydrous dichloromethane was treated with dicyclohexylcarbodiimide (1.35 g, 6.56 mmole) followed by 4-dimethylaminopyridine (0.8 g, 6.56 mm mole). After stirring overnight at ambient temperature, the precipitated solid was collected and washed with dichloromethane. The combined filtrates were concentrated *in vacuo* to give an amorphous amber solid. Flash chromatography of the crude product (on silica Merck 60, elution with hexane-ethylacetate 1:1 v/v) gave partially purified title compound. Pure product (0.8 g, 19.6%) was obtained by preparative HPLC (Waters Prep 500, silica gel, hexane-ethylacetate 3:2 v/v, flow rate 250 mL/min). HPLC analysis showed that the monoester is a 9:1 mixture of two conformers.

30

35

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1H NMR (CDCl₃, 400 MHz): δ 1.438 (m, 9H, COOBu^t), 1.455 (s, 9H, COOBu^t), 1.652 (s, 3H, CH₃C=C), 1.752 (s, 3H, CH₃C=C), 3.14 (s, 3H, CH₃O), 3.33 (s, 3H, CH₃O), 3.37 (s, 3H, CH₃O), 4.18 (d, 1H, CHO), 4.72 (m, 1H, 42-CHO), 4.79 (s, 1H, OH); High Res. MS (neg. ion FAB): Calcd for C₆₇H₁₀₇N₃O₁₈:
5 1241.7549, measured mass 1241.7604.
Anal. Calcd for C₆₇H₁₀₇N₃O₁₈: C, 64.76; H, 8.68; N, 3.38
Found: C, 64.58; H, 9.01; N, 3.10

10 Example 13

Rapamycin-31,42-diester with N^α,N^ε-bis[(1,1-dimethylethoxy)carbonyl]-L-lysine

Under a nitrogen atmosphere, a solution of N^α,N^ε bis-Boc-L-lysine (1.038 g,
15 3 mmole) and triethylamine (0.42 mL, 3 mmole) in 10 mL of anhydrous THF was
treated in one portion with 2,4,6-trichlorobenzoyl chloride (0.73 g, 3 mmole). After
stirring for 20 minutes at ambient temperature, the precipitated solid was collected and
the filtrate was concentrated *in vacuo*. The resulting mixed anhydride was dissolved in
5 mL of benzene and added to a stirred solution of rapamycin (1 g, 1.09 mmole)
20 containing 4-dimethylamino pyridine (0.59 g, 4.8 mmole) in 10 mL of benzene. After
stirring at ambient temperature overnight, the precipitated solid was collected and the
filtrate was evaporated to dryness (yellow foam). The crude product was purified by
flash chromatography (on silica Merck 60, elution with hexane-ethylacetate 1:1) to
provide title compound (1.15 g, 67%). HPLC analysis shows that the diester is a 9:1
25 mixture of two conformers.

1H NMR (CDCl₃, 400 MHz): δ 1.426 (m, 9H, COOBu^t), 1.438 (s, 9H, COOBu^t),
1.443 (s, 9H, COOBu^t), 1.446 (s, 9H, COOBu^t), 3.141 (s, 3H, CH₃O), 3.36 (s, 3H,
CH₃O), 3.378 (s, 3H, CH₃O), 4.68-4.76 (m, 2H, OH and 42-CHO); High res. MS
(neg. ion FAB): Calcd. for C₈₃H₁₃₅N₅O₂₃ 1569.9526, measured mass 1569.9537.
30 Anal. Calcd. for C₈₃H₁₃₅N₅O₂₃: C, 63.46; H, 8.66; N, 4.46
Found: C, 63.06; H, 8.84; N, 4.09

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Example 14.

Rapamycin-14,31,42-tris(monobenzylsuccinate)

5 To a solution of 5.0 g (5.47 mmol) of rapamycin, 3.41 g (16.41 mmol) of monobenzylsuccinate, and 3.15 g (16.41 mmol) of 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride in 20 mL of dry dichloromethane was added 200 mg of 4-dimethylaminopyridine. The solution was stirred at room temperature for 3 days. The reaction mixture was poured into 2 N HCl and extracted three times with ethyl 10 acetate. The organic layers were combined, washed with brine, dried over anhydrous sodium sulfate, decanted, and concentrated in vacuo to give a light yellow foam. Flash chromatography on a 60 mm x 150 mm silica gel column eluting with 20 % ethyl acetate/hexane to 75 % ethyl acetate/hexane gave three fractions. Fraction #1, upon 15 concentration, gave 330 mg (4.1 %) of pure rapamycin-14,31,42-tris-(monobenzylsuccinate).

¹H NMR (CDCl₃, 400 MHz) δ 7.353 (bs, 15 H, *arom*), 5.168 (d, J = 2.0 Hz, 1 H, CH-O₂C), 5.148 (m, 6 H, CH₂Ph), 4.672 (m, 1 H, CO₂CH-CHOMe), 3.355 (s, 3 H, CH₃O-), 3.337 (s, 3 H, CH₃O-), 3.327 (s, 3 H, CH₃O-), 2.697 (m, 12 H, O₂CCH₂CH₂CO₂CH₂Ph), 1.745 (s, 3 H, CH₃C=C), 1.655 (s, 3 H, CH₃C=C); 20 IR (KBr) 3450 (OH), 2950 (CH), 1745 (C=O), 1650, 1460, 1385, 1360, 1160, 1105, 995 cm⁻¹.

Analysis Calcd for C₈₄H₁₀₉NO₂₁ · 3 H₂O C 66.27; H 7.56; N 0.92
Found C 65.96; H 7.24; N 1.00

25 The following representative compounds can be prepared from rapamycin and the appropriate half acid-ester by employing the method used to prepare the title compound in Example 14.

30 Rapamycin-14,31,42-tris (monomethylsuccinate)
Rapamycin-14,31,42-tris (monophenyl-3',3'-dimethylglutarate)
Rapamycin-14,31,42-tris (mono t-butyl-3'-methylglutarate)
Rapamycin-14,31,42-tris (monobenzylthiodiglycolate)
Rapamycin-14,31,42-tris (monohexyldiglycolate)
Rapamycin-14,31,42-tris (monopropylphthalate)
35 Rapamycin-14,31,42-tris (monoethyl-2',6'-pyridinedicarboxylate)

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Example 15.

Rapamycin-31,42-bis(monobenzylsuccinate)

5 Fraction # 2, obtained from the procedure employed in Example 14, gave 1.25 g (17.7 %) of pure rapamycin-31,42-bis(monobenzylsuccinate) upon concentration.

¹H NMR (CDCl₃, 400 MHz) δ 7.351 (bs, 10 H, *arom*), 5.168 (d, *J* = 2.0 Hz, 1 H, *CH*-O₂C), 5.125 (m, 4 H, *CH*₂Ph), 4.680 (m, 1 H, CO₂CH-CHOMe), 3.356 (s, 3 H, *CH*₃O-), 3.329 (s, 3 H, *CH*₃O-), 3.146 (s, 3 H, *CH*₃O-), 2.639 (m, 8 H, O₂CCH₂CH₂CO₂CH₂Ph), 1.748 (s, 3 H, *CH*₃C=C), 1.654 (s, 3 H, *CH*₃C=C); IR (KBr) 3450 (OH), 2940 (CH), 1740 (C=O), 1650, 1455, 1380, 1355, 1160, 1105, 995 cm⁻¹; MS (neg. ion FAB) 1294 (M-), 1202, 1103, 1012, 590, 511, 475, 297, 207, 167, 148, 99 (100); High Res. MS (neg. ion FAB) Calcd for C₇₃H₉₉NO₁₉ 15 1293.68108, found 1293.6811.

20 The following representative compounds can be prepared from rapamycin and the appropriate half acid-ester by employing the method used to prepare the title compound in Example 15.

25 Rapamycin-31,42-bis (monomethylsuccinate)
 Rapamycin-31,42-bis (monophenyl-3',3'-dimethylglutarate)
 Rapamycin-31,42-bis (mono t-butyl-3'-methylglutarate)
 Rapamycin-31,42-bis (monobenzylthiodiglycolate)
 Rapamycin-31,42-bis (monohexyldiglycolate)
 Rapamycin-31,42-bis (monopropylphthalate)
 30 Rapamycin-31,42-bis (monoethyl-2',6'-pyridinedicarboxylate)

Example 16.

35 Rapamycin-42-(monobenzylsuccinate)

Fraction # 3, obtained from the procedure employed in Example 14, gave 930 mg (15.4 %) of pure rapamycin-42-monobenzylsuccinate upon concentration.

- 24 -

¹H NMR (CDCl₃, 400 MHz) δ 7.355 (bs, 5 H, *arom*), 5.141 (m, 2 H, CH₂Ph), 4.680 (m, 1 H, CO₂CH-CHOMe), 3.364 (s, 3 H, CH₃O-), 3.333 (s, 3 H, CH₃O-), 3.141 (s, 3 H, CH₃O-), 2.698 (m, 4 H, O₂CCH₂CH₂CO₂CH₂Ph), 1.751 (s, 3 H, CH₃C=C), 1.655 (s, 3 H, CH₃C=C); IR (KBr) 3450 (OH), 2940 (CH), 1740 (C=O), 1645, 1455, 1380, 1165, 1105, 990 cm⁻¹; MS (neg. ion FAB) 1103 (M-), 1045, 1012, 624, 590, 167, 99 (100); High Res. MS (neg. ion FAB) Calcd for C₆₂H₈₉NO₁₆ 1103.6181, found 1103.6048.

10

The following representative compounds can be prepared from rapamycin and the appropriate half acid-ester by employing the method used to prepare the title compound in Example 16.

15 Rapamycin-42-(monomethylsuccinate)
 Rapamycin-42-monophenyl-3',3'-dimethylglutarate)
 Rapamycin-42-(mono t-butyl-3'-methylglutarate)
 Rapamycin-42-(monobenzylthiodiglycolate)
 Rapamycin-42-(monohexyldiglycolate)
 Rapamycin-42-(monopropylphthalate)
 Rapamycin-42-(monoethyl-2',6'-pyridinedicarboxylate)

Example 17.

25

Rapamycin-31,42-bishemiglutarate

To a solution of 2.0 g (2.2 mmol) of rapamycin in 10 mL of dry dichloromethane was added 1.24 g (10.9 mmol) of glutaric anhydride followed by 30 881 uL (861 mg, 10.9 mmol) of pyridine. To this was added 200 mg of 4-dimethylaminopyridine and the reaction mixture was allowed to reflux for 8 h. The solution was cooled to room temperature, poured into 2 N HCl, and extracted three times with dichloromethane. The combined organic extracts were washed with brine, dried over anhydrous sodium sulfate, decanted, and concentrated in vacuo to give a 35 yellow foam. The crude product was purified via reverse phase HPLC on a C18 column eluting starting with 60 % acetonitrile/water. Collected, after, concentration, 586 mg (24 %) of rapamycin-31,42-bishemiglutarate.

- 25 -

1H NMR (CDCl₃, 400 MHz) δ 5.398 (m, 1 H, -CO₂CHCHOMe), 4.683 (m, 1 H, -CO₂CHCHOMe), 3.364 (s, 3 H, CH₃O-), 3.362 (s, 3 H, CH₃O-), 3.106 (s, 3 H, CH₃O-), 2.407 (m, 8 H, -O₂CCH₂CH₂CH₂CO₂H), 1.960 (m, 4 H, -O₂CCH₂CH₂CH₂CO₂H), 1.770 (s, 3 H, CH₃C=C), 1.653 (s, 3 H, CH₃C=C);
 5 ¹³C NMR (CDCl₃, MHz) 211.45 (C=O), 206.84 (C=O), 200.44 (C=O), 177.83 (C=O), 177.04 (C=O), 172.43 (C=O), 171.20 (C=O), 165.27 (C=O), 159.08 (C=O);
 IR (KBr) 3430 (OH), 2940 (CH), 2880 (CH), 1745 (C=O), 1685, 1625, 1580, 1450, 1385, 1330, 1200, 1140, 1100, 990 cm⁻¹; MS (neg. ion FAB) 1140 (M-H), 1122, 1026, 990, 946, 913, 590, 475, 435, 321, 167, 148, 131 (100), 113; High Res.
 10 MS (neg. ion FAB) Calcd for C₆₁H₉₀O₁₉N (M-H) 1140.6107, Found 1140.6106.
 Analysis Calcd for C₆₁H₉₁O₁₉N · H₂O C 63.15; H 8.02; N 1.20
 Found C 63.35; H 7.88; N 1.40

15 The following representative compounds can be prepared from rapamycin and the appropriate anhydride by employing the method used to prepare the title compound in Example 17.

20 Rapamycin-31,42-bishemi-3'-methylglutarate
Rapamycin-31,42-bishemi-3',3'-dimethylglutarate
Rapamycin-31,42-bishemi-3'-oxoglutarate
Rapamycin-31,42-bishemi-3'-thioglutarate
Rapamycin-31,42-bishemi-phthalate
Rapamycin-31,42-bishemi-2',3'-pyridine dicarboxylate

25

Example 18.

Rapamycin-31,42-hemiglutarate bisodium salt

Purified bis-31,42-hemiglutamate of rapamycin (740 mg, 649 umol), prepared as described in Example 17, was dissolved in 5 mL of 95 % ethanol and 107 mg (1.27 mmol) of sodium bicarbonate was added. Water (1 mL) was added to completely dissolve the salt. Once dissolved, the light yellow solution was concentrated in vacuo to give a foamy yellow solid. The foam was dried in a drying pistol for 24 h, refluxing over acetone at reduced pressure to give 520 mg of the bisodium salt.

- 26 -

¹H NMR (d₆-DMSO, 400 MHz) δ 5.235 (m, 1 H, -CHO₂C), 4.498 (m, 1 H, MeOCHCHO₂C-), 3.287 (s, 6 H, 2 CH₃O-), 3.236 (s, 3 H, CH₃O-), 2.245 (m, 8 H, O₂CCH₂CH₂CH₂CO₂⁻), 1.712 (s, 3 H, CH₃C=C), 1.593 (s, 3 H, CH₃C=C);
IR (KBr) 3420 (OH), 2920 (CH), 1725 (C=O), 1675, 1620, 1560, 1450, 1400, 1375,
5 1230, 1195, 1130, 1090, 980 cm⁻¹; MS (neg. ion FAB) 1112 (M-1, free acid), 994, 589, 475, 297, 167, 148, 117, 99 (100); High Res. MS (neg. ion FAB) Calcd for C₆₁H₈₉O₁₉NNa (M-Na) 1162.5926, Found 1162.5899.

Analysis Calcd for C₆₁H₈₉O₁₉NNa₂ · H₂O C 60.85; H 7.56; N 1.16
Found C 60.67; H 7.36; N 1.58

10

Example 19.

Rapamycin-31,42-bishemiglutamate bistromethamine salt

15

Purified bis-31,42 hemiglutamate of rapamycin (950 mg, 833 umol), prepared as described in Example 17, was dissolved in 5 mL of 95 % ethanol and 197 mg (1.63 mmol) of tris(hydroxymethyl)methylamine was added. Water (1 mL) was added to completely dissolve the amine. Once dissolved, the yellow solution was 20 concentrated in vacuo to give a foamy yellow solid. The very hygroscopic foam was dried in a drying pistol for 24 h, refluxing over acetone at reduced pressure to give 900 mg (78 %) of the bistromethamine salt.

25

¹H NMR (d₆-DMSO, 400 MHz) δ 5.253 (m, 1 H, -CHO₂C), 4.523 (m, 1 H, MeOCHCHO₂C-), 3.347 (s, 6 H, 2 CH₃O-), 3.276 (s, 3 H, CH₃O-), 2.289 (m, 8 H, O₂CCH₂CH₂CH₂CO₂⁻), 1.681 (s, 3 H, CH₃C=C), 1.595 (s, 3 H, CH₃C=C);
IR (KBr) 3400 (OH), 2920 (CH), 1730 (C=O), 1620, 1555, 1450, 1400, 1370, 1185, 1060, 980 cm⁻¹; MS (neg. ion FAB) 1140 (M-H, free acid), 1028, 167, 148, 131, 30 100, 113; High Res. MS (neg. ion FAB) Calcd for C₆₁H₉₀O₁₉N (M-H, free acid) 1140.6107, Found 1140.6069.

Analysis Calcd for C₆₉H₁₀₃O₂₅N₃ · 2 H₂O C 58.77; H 7.58; N 2.98
Found C 58.47; H 7.94; N 3.58

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Example 20.

Rapamycin-42-hemi-3'-oxoglutarate

5 To a solution of 3.0 g (3.3 mmol) of rapamycin in 20 mL of dry dichloromethane was added 1.90 g (16.4 mmol) of diglycolic anhydride followed by 1.32 mL (1.29 g, 16.4 mmol) of pyridine. To this was added 200 mg of 4-dimethylaminopyridine and the reaction mixture was allowed to stir at room temperature for 2 days. The solution was cooled to room temperature, poured into 2 N 10 HCl, and extracted three times with dichloromethane. The combined organic extracts were washed with brine, dried over anhydrous sodium sulfate, decanted, and concentrated in vacuo to give a yellow foam. The crude product was purified via reverse phase HPLC on a C₁₈ column eluting starting with 60 % acetonitrile/water. After concentration, 870 mg (26 %) of rapamycin-42-hemi-3'-oxoglutarate and 15 500 mg (13 %) of rapamycin-31,42-bishemi-3'oxoglutarate were isolated.

1H NMR (CDCl₃, 400 MHz) δ 4.768 (m, 1 H, CO₂CH-CHOMe), 4.250 (m, 4 H, O₂CCH₂OCH₂CO₂), 3.356 (s, 3 H, CH₃O-), 3.331 (s, 3 H, CH₃O-), 3.139 (s, 3 H, CH₃O-), 1.759 (s, 3 H, CH₃C=C), 1.653 (s, 3 H, CH₃C=C); IR (KBr) 3420 (OH), 2920 (CH), 2875 (CH), 1740 (C=O), 1720 (C=O), 1640, 1625, 20 1445, 1370, 1320, 1200, 1135, 1095, 980 cm⁻¹; MS (neg. ion FAB) 1028 (M - H), 327, 167 (100), 148, 133, 115; High Res. MS (neg. ion FAB) Calcd for C₅₅H₈₂O₁₇N (M - H) 1028.5597, Found 1028.5599.

Analysis Calcd for C₅₅H₈₃O₁₇N · 3 H₂O C 60.97; H 8.22; N 1.29
Found C 61.33; H 7.74; N 1.69

25 The following representative compounds can be prepared from rapamycin and the appropriate half acid-ester by employing the method used to prepare the title compound in Example 20.

30 Rapamycin-42-hemi-3'-methylglutarate
Rapamycin-42-hemi-3',3'-dimethylglutarate
Rapamycin-42-hemi-3'-thioglutamate
Rapamycin-42-hemi-phthalate
Rapamycin-42-hemi-2',3'-pyridine dicarboxylate

35

Example 21.

Rapamycin-31,42-bishemi-3'-oxoglutarate

5 To a solution of 5.0 g (5.47 mmol) of rapamycin in 20 mL of dry dichloromethane was added 3.17 g (27.3 mmol) of diglycolic anhydride followed by 2.17 mL (2.12 g, 27.3 mmol) of pyridine. To this was added 400 mg of 4-dimethylaminopyridine and the reaction mixture was allowed to stir at reflux for 24 h. The solution was cooled to room temperature, poured into 2 N HCl, and extracted three
 10 times with dichloromethane. The combined organic extracts were washed with brine, dried over anhydrous sodium sulfate, decanted, and concentrated in vacuo to give a yellow foam. The crude product was purified via reverse phase HPLC on a C₁₈ column eluting starting with 60 % acetonitrile/water. After concentration, 1.75 g (28 %) of rapamycin-31,42-bis(hemi-3'-oxoglutarate was isolated.

15 ^1H NMR (CDCl₃, 400 MHz) δ 4.785 (m, 1 H, CO₂CHCHOMe), 4.260 (m, 8 H, O₂CCH₂OCH₂CO₂), 3.360 (s, 3 H, CH₃O-), 3.343 (s, 3 H, CH₃O-), 3.143 (s, 3 H, CH₃O-), 1.775 (s, 3 H, CH₃C=C), 1.656 (s, 3 H, CH₃C=C); ^{13}C NMR (CDCl₃, MHz) 211.12 (C=O), 207.73 (C=O), 193.11 (C=O), 171.90 (C=O), 171.59 (C=O), 170.15 (C=O), 169.35 (C=O), 168.83 (C=O), 166.63 (C=O);
 20 IR (KBr) 3420 (OH), 2920 (CH), 2850 (CH), 1740 (C=O), 1645, 1625, 1440, 1370, 1190, 11300, 980 cm⁻¹; MS (neg. ion FAB) 1140 (M-H), 1122, 1026, 990, 946, 913, 590, 475, 435, 321, 167, 148, 131 (100), 113; High Res. MS (neg. ion FAB) Calcd for C₅₉H₈₆O₂₁N (M - H) 1144.5701. Found 1144.5702

Example 22.

30 Rapamycin-31,42-bishemi-3'-oxoglutarate disodium salt

Purified bis-31,42 hemi-3'-oxoglutarate of rapamycin (720 mg, 629 μ mol), prepared by the procedure employed in Example 21, was dissolved in 10 mL of 95 % ethanol and 106 mg (1.26 mmol) of sodium bicarbonate was added. Water (1 mL) was added to completely dissolve the salt. Once dissolved, the light yellow solution was concentrated in vacuo to give a foamy yellow solid. The foam was dried in a drying

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pistol for 48 h, refluxing over dichloromethane at reduced pressure to give 435 mg (58 %) of the disodium salt.

¹H NMR (d₆-DMSO, 400 MHz) δ 4.975 (m, 1 H, -CHO₂C), 4.593 (m, 1 H, MeOCHCHO₂C-), 4.135 (s, 2 H, -O₂CCH₂OCH₂CO₂R), 3.617 (s, 2 H, -O₂CCH₂OCH₂CO₂R), 3.299 (s, 6 H, 2 CH₃O-), 3.232 (s, 3 H, CH₃O-), 1.614 (s, 3 H, CH₃C=C), 1.553 (s, 3 H, CH₃C=C); IR (KBr) 3420 (OH), 2920 (CH), 1735 (C=O), 1615, 1445, 1395, 1380, 1320, 1220, 1130, 1090, 980 cm⁻¹; MS (neg. ion FAB) 1188 (M-1), 1166 (M-Na), 1144, 1051, 1028, 590, 459, 167, 155 (100), 148, 133, 115.

Example 23.

15 Rapamycin-31,42-bishemi-3'-oxoglutarate bistromethamine salt

Purified bis-31,42 hemi-3'-oxoglutarate of rapamycin (1.01 g, 882 umol), prepared by the procedure employed in Example 21, was dissolved in 10 mL of 95 % ethanol and 213 mg (1.76 mmol) of tris(hydroxymethyl)- methylamine was added. Water (1 mL) was added to completely dissolve the amine. Once dissolved, the yellow solution was concentrated in vacuo to give a foamy yellow solid. The very hygroscopic foam was dried in a drying pistol for 48 h, refluxing over dichloromethane at reduced pressure to give 805 mg (66 %) of the bistromethamine salt.

25
¹H NMR (d₆-DMSO, 400 MHz) δ 4.955 (m, 1 H, -CHO₂C), 4.600 (m, 1 H, MeOCHCHO₂C-), 4.149 (s, 2 H, -O₂CCH₂OCH₂CO₂R), 3.770 (s, 2 H, -O₂CCH₂OCH₂CO₂R), 3.407 (s, 6 H, 2 CH₃O-), 3.257 (s, 3 H, CH₃O-), 1.806 (s, 3 H, CH₃C=C), 1.614 (s, 3 H, CH₃C=C); IR (KBr) 3400 (OH), 2920 (CH), 1730 (C=O), 1620, 1550, 1450, 1395, 1370, 1200, 1060, 985 cm⁻¹; MS (neg. ion FAB) 1144 (M-H, free acid), 1028, 167, 148, 133 (100), 115.
30 Analysis Calcd for C₆₇H₁₀₉O₂₇N₃ · H₂O C 57.22; H 7.90; N 2.98
Found C 57.26; H 7.90; N 3.15

35

- 30 -

Example 24.

Rapamycin-31,42-bishemisuccinate.

5 To a solution of 2.0 g (2.2 mmol) of rapamycin in 10 mL of dry dichloromethane was added 1.19 g (10.9 mmol) of succinic anhydride followed by 881 μ L (861 mg, 10.9 mmol) of pyridine. To this was added 200 mg of 4-dimethylamino-pyridine and the reaction mixture refluxed for 24 h. The solution was cooled to room temperature, poured into 2 N HCl, and extracted three times with dichloromethane.

10 The combined organic extracts were washed with brine, dried over anhydrous sodium sulfate, decanted, and concentrated in vacuo to give a yellow foam. The crude product was purified via reverse phase HPLC on a C₁₈ column gradient eluting starting with 20 % acetonitrile/water to 60 % acetonitrile/water. Collected, after, concentration, 770 mg (31 %) of rapamycin-31,42-bishemisuccinate.

15 The purified bis-31,42 hemisuccinate of rapamycin (770 mg, 686 umol) was dissolved in 10 mL of 95 % ethanol and 166 mg (1.37 mmol) of tris(hydroxymethyl)-methylamine was added. Water (1 mL) was added to completely dissolve the amine. Once dissolved, the yellow solution was concentrated in vacuo to give a foamy yellow solid. The very hygroscopic foam was dried in a drying pistol for 24 h, refluxing over acetone at reduced pressure to give 890 mg (95 %) of the bistromethamine salt. The bistromethane salt was evaluated in the standard pharmacological test procedures.

25 ¹H NMR (d₆-DMSO, 400 MHz) 5.231 (m, 1 H, -CHO₂C), 4.554 (m, 1 H, MeOCHCHO₂C-), 3.426 (s, 6 H, 2 CH₃O-), 3.249 (s, 3 H, CH₃O-), 2.431 (m, 8 H, O₂CCH₂CH₂CO₂⁻), 1.700 (s, 3 H, CH₃C=C), 1.554 (s, 3 H, CH₃C=C); ¹³C NMR (d₆-DMSO,) 211.28 (C=O), 205.23 (C=O), 199.59 (C=O), 174.86 (C=O), 173.62 (C=O), 171.72 (C=O), 171.50 (C=O), 166.56 (C=O), 166.53 (C=O); IR (KBr) 3420 (OH), 2940 (CH), 1735 (C=O), 1630, 1580, 1460, 1400, 1380, 1170, 1070, 30 990 cm⁻¹; MS (neg. ion FAB) 1112 (M-1, free acid), 994, 589, 475, 297, 167, 148, 117, 99 (100).

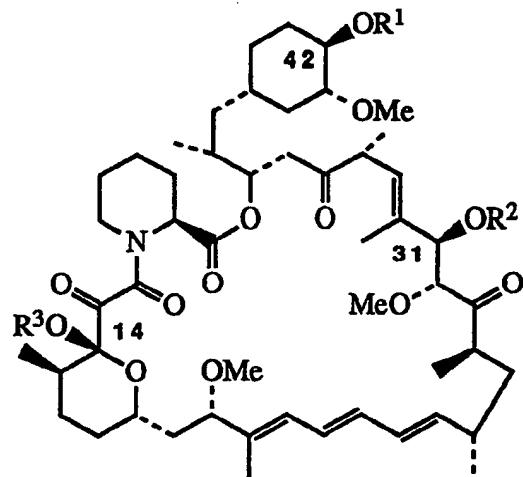
Analysis Calcd for C₆₇H₁₀₉O₂₅N₃ · 2 H₂O C 57.80; H 8.12; N 3.01
Found C 57.91; H 8.21; N 2.37

CLAIMS

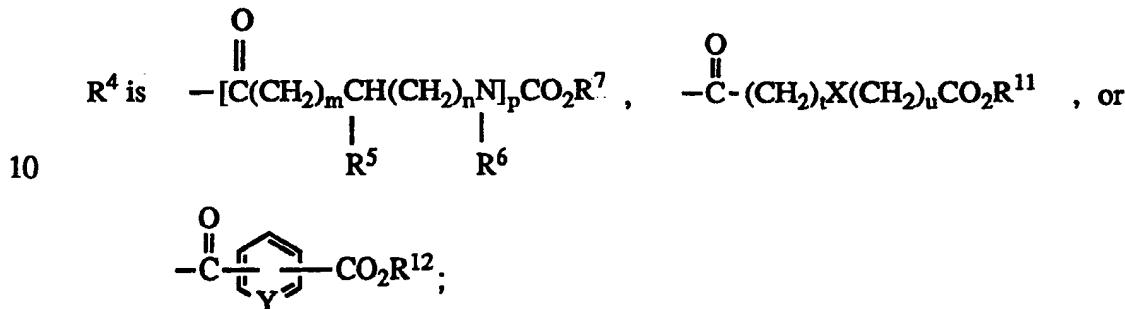
What is claimed is:

1. A compound of the structure

5



wherein R¹, R², and R³ are each, independently, hydrogen, or R⁴;



15 R⁵ is hydrogen, alkyl of 1-6 carbon atoms, aralkyl of 7-10 carbon atoms, -(CH₂)_qCO₂R⁸, -(CH₂)_rNR⁹CO₂R¹⁰, carbamylalkyl of 2-3 carbon atoms, aminoalkyl of 1-4 carbon atoms, hydroxyalkyl of 1-4 carbon atoms, guanylalkyl of 2-4 carbon atoms, mercaptoalkyl of 1-4 carbon atoms, alkylthioalkyl of 2-6 carbon atoms, indolylmethyl, hydroxyphenylmethyl, imidazoylmethyl or phenyl which is optionally mono-, di-, or tri-substituted with a substituent selected from alkyl of 1-6 carbon atoms, alkoxy of 1-6 carbon atoms, hydroxy, cyano, halo, nitro, carbalkoxy of 2-7 carbon atoms, trifluoromethyl, amino, or a carboxylic acid;

20

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R^6 and R^9 are each, independently, hydrogen, alkyl of 1-6 carbon atoms, or aralkyl of 7-10 carbon atoms;

5 R^7 , R^8 , and R^{10} are each, independently, alkyl of 1-6 carbon atoms, aralkyl of 7-10 carbon atoms, fluorenylmethyl, or phenyl which is optionally mono-, di-, or tri-substituted with a substituent selected from alkyl of 1-6 carbon atoms, alkoxy of 1-6 carbon atoms, hydroxy, cyano, halo, nitro, carbalkoxy of 2-7 carbon atoms, trifluoromethyl, amino, or a carboxylic acid;

10 R^{11} and R^{12} are each, independently, alkyl of 1-6 carbon atoms, aralkyl of 7-10 carbon atoms, or phenyl which is optionally mono-, di-, or tri-substituted with a substituent selected from alkyl of 1-6 carbon atoms, alkoxy of 1-6 carbon atoms, hydroxy, cyano, halo, nitro, carbalkoxy of 2-7 carbon atoms, trifluoromethyl, amino, or a carboxylic acid;

15 X is $\begin{array}{c} R^{13} \\ | \\ -C- \\ | \\ R^{14} \end{array}$, O, or S;

15 R^{13} and R^{14} are each, independently, hydrogen or alkyl of 1-6 carbon atoms;

Y is CH or N;

m is 0 - 4;

n is 0 - 4;

20 p is 1 - 2;

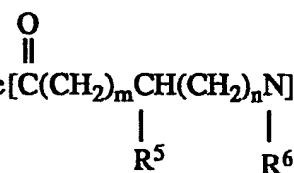
q is 0 - 4;

r is 0 - 4;

t is 0 - 4;

u is 0 - 4;

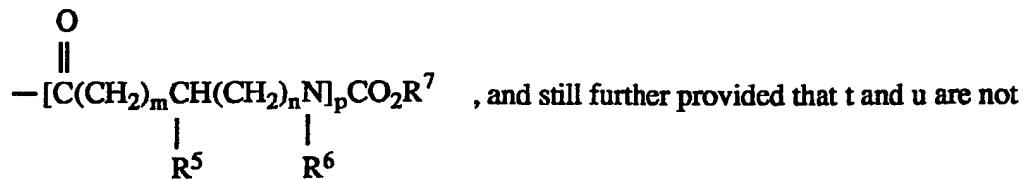
25 wherein R^5 , R^6 , m, and n are independent in each of the $[C(CH_2)_mCH(CH_2)_nN]$



subunits when p = 2;

or a pharmaceutically acceptable salt thereof, with the proviso that R^1 , R^2 , and R^3 are not all hydrogen, further provided that R^1 , R^2 , and R^3 are not all

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2. A compound of claim 1 where R^4 is

$$-\left[\text{C}(\text{CH}_2)_m\text{CH}(\text{CH}_2)_n\text{N}\right]_p\text{CO}_2\text{R}^7$$

$\begin{array}{c} \text{O} \\ \parallel \\ | \quad | \\ \text{C}(\text{CH}_2)_m \quad \text{CH}(\text{CH}_2)_n \end{array}$
 $\begin{array}{c} \text{N} \\ | \\ \text{R}^5 \end{array}$
 $\begin{array}{c} \text{N} \\ | \\ \text{R}^6 \end{array}$

5 $\text{m} = 0, \text{n} = 0$, and $\text{p} = 1$ or a pharmaceutically acceptable salt thereof.

3. A compound of claim 1 where R^4 is

$$-\left[\text{C}(\text{CH}_2)_m\text{CH}(\text{CH}_2)_n\text{N}\right]_p\text{CO}_2\text{R}^7$$

$\begin{array}{c} \text{O} \\ \parallel \\ | \quad | \\ \text{C}(\text{CH}_2)_m \quad \text{CH}(\text{CH}_2)_n \end{array}$
 $\begin{array}{c} \text{N} \\ | \\ \text{R}^5 \end{array}$
 $\begin{array}{c} \text{N} \\ | \\ \text{R}^6 \end{array}$

$\text{m} = 0, \text{n} = 0$, and $\text{p} = 2$ or a pharmaceutically acceptable salt thereof.

4. A compound of claim 1 where R^4 is

$$-\left[\text{C}(\text{CH}_2)_m\text{CH}(\text{CH}_2)_n\text{N}\right]_p\text{CO}_2\text{R}^7$$

$\begin{array}{c} \text{O} \\ \parallel \\ | \quad | \\ \text{C}(\text{CH}_2)_m \quad \text{CH}(\text{CH}_2)_n \end{array}$
 $\begin{array}{c} \text{N} \\ | \\ \text{R}^5 \end{array}$
 $\begin{array}{c} \text{N} \\ | \\ \text{R}^6 \end{array}$

10 $\text{n} = 0$, and R^5 is $-(\text{CH}_2)_q\text{CO}_2\text{R}^8$ or a pharmaceutically acceptable salt thereof.

5. A compound of claim 1 where R^4 is

$$-\left[\text{C}(\text{CH}_2)_m\text{CH}(\text{CH}_2)_n\text{N}\right]_p\text{CO}_2\text{R}^7$$

$\begin{array}{c} \text{O} \\ \parallel \\ | \quad | \\ \text{C}(\text{CH}_2)_m \quad \text{CH}(\text{CH}_2)_n \end{array}$
 $\begin{array}{c} \text{N} \\ | \\ \text{R}^5 \end{array}$
 $\begin{array}{c} \text{N} \\ | \\ \text{R}^6 \end{array}$

$\text{m} = 0, \text{n} = 0$, and R^5 is $-(\text{CH}_2)_r\text{NR}^9\text{CO}_2\text{R}^{10}$ or a pharmaceutically acceptable salt thereof.

6. A compound of claim 1 where R^4 is

$$-\left[\text{C}(\text{CH}_2)_m\text{CH}(\text{CH}_2)_n\text{N}\right]_p\text{CO}_2\text{R}^7$$

$\begin{array}{c} \text{O} \\ \parallel \\ | \quad | \\ \text{C}(\text{CH}_2)_m \quad \text{CH}(\text{CH}_2)_n \end{array}$
 $\begin{array}{c} \text{N} \\ | \\ \text{R}^5 \end{array}$
 $\begin{array}{c} \text{N} \\ | \\ \text{R}^6 \end{array}$

$\text{m} = 0, \text{n} = 0$, and R^5 is hydrogen or a pharmaceutically acceptable salt thereof.

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7. A compound of claim 1 where R⁴ is $-\text{C}(=\text{O})-(\text{CH}_2)_t\text{X}(\text{CH}_2)_u\text{CO}_2\text{R}^{11}$ or a pharmaceutically acceptable salt thereof.

5 8. A compound of claim 1 which is rapamycin-42-ester with N-[(1,1-dimethylethoxy)carbonyl]-glycylglycine or a pharmaceutically acceptable salt thereof.

9. A compound of claim 1 which is rapamycin-31,42-diester with N-[(1,1-dimethyl- ethoxy)carbonyl]-glycylglycine or a pharmaceutically acceptable salt thereof.

10 10. A compound of claim 1 which is rapamycin-31,42-diester with N-[(1,1-dimethylethoxy)carbonyl]-N-methylglycine or a pharmaceutically acceptable salt thereof.

11. A compound of claim 1 which is rapamycin-42-ester with N-[(1,1-dimethylethoxy)carbonyl]-N-methylglycine or a pharmaceutically acceptable salt thereof.

15 12. A compound of claim 1 which is rapamycin-31,42-diester with 5-(1,1-dimethylethoxy)-2-[[[(1,1-dimethylethoxy)carbonyl]amino]-5-oxopentanoic acid or a pharmaceutically acceptable salt thereof.

20 13. A compound of claim 1 which is rapamycin-42-ester with 5-(1,1-dimethylethoxy)-2-[[[(1,1-dimethylethoxy)carbonyl]amino]-5-oxopentanoic acid or a pharmaceutically acceptable salt thereof.

25 14. A compound of claim 1 which is rapamycin-31,42-diester with 2-[[[(1,1-dimethylethoxy)carbonyl]amino]-4-oxo-4-(phenylmethoxy) butanoic acid or a pharmaceutically acceptable salt thereof.

30 15. A compound of claim 1 which is rapamycin-31,42-diester with 3-[[[(1,1-dimethylethoxy)carbonyl]amino]-4-oxo-4-(phenylmethoxy) butanoic acid or a pharmaceutically acceptable salt thereof.

35 16. A compound of claim 1 which is rapamycin-42-ester with 3-[[[(1,1-dimethylethoxy)carbonyl]amino]-4-oxo-4-(phenylmethoxy) butanoic acid or a pharmaceutically acceptable salt thereof.

- 35 -

17. A compound of claim 1 which is rapamycin-42-ester with 5-(1,1-dimethoxy)-4-[[[(1,1-dimethylethoxy)carbonyl]amino]-5-oxopentanoic acid or a pharmaceutically acceptable salt thereof.
5
18. A compound of claim 1 which is rapamycin-31,42-diester with 5-(1,1-dimethylethoxy)-4-[[[(1,1-dimethylethoxy)carbonyl]amino]-5-oxopentanoic acid or a pharmaceutically acceptable salt thereof.
- 10 19. A compound of claim 1 which is rapamycin-42-ester with N^α, N^ε-bis[(1,1-dimethylethoxy)carbonyl]-L-lysine or a pharmaceutically acceptable salt thereof.
20. A compound of claim 1 which is rapamycin-31,42-diester with N^α, N^ε-bis[(1,1-dimethylethoxy)carbonyl]-L-lysine or a pharmaceutically acceptable salt
15 thereof.
21. A compound of claim 1 which is rapamycin-14,31,42-tris(monobenzylsuccinate) or a pharmaceutically acceptable salt thereof.
22. A compound of claim 1 which is rapamycin-31,42-bis(monobenzylsuccinate)
20 or a pharmaceutically acceptable salt thereof.
23. A compound of claim 1 which is rapamycin-42-(monobenzylsuccinate) or a pharmaceutically acceptable salt thereof.
- 25 24. A compound of claim 1 which is rapamycin-31,42-bishemiglutarate or a pharmaceutically acceptable salt thereof.
25. A compound of claim 1 which is rapamycin-31,42-hemiglutarate bissodium salt.
30
26. A compound of claim 1 which is rapamycin-31,42-bishemiglutarate bistrormethamine salt.
27. A compound of claim 1 which is rapamycin-42-hemi-3'-oxoglutarate or a
35 pharmaceutically acceptable salt thereof.

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28. A compound of claim 1 which is rapamycin-31,42-bishemi-3'-oxoglutarate or a pharmaceutically acceptable salt thereof.

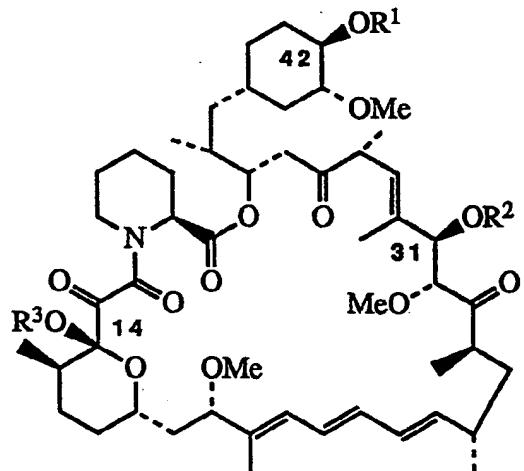
29. A compound of claim 1 which is rapamycin-31,42-bishemi-3'-oxoglutarate 5 disodium salt.

30. A compound of claim 1 which is rapamycin-31,42-bishemi-3'-oxoglutarate bistromethamine salt.

10 31. A compound of claim 1 which is rapamycin-31,42-bishemisuccinate or a pharmaceutically acceptable salt thereof.

32. A compound of claim 1 which is rapamycin-31,42-bishemisuccinate 15 bistromethane salt.

33. A method of treating transplantation rejection, host vs. graft disease, autoimmune diseases, and diseases of inflammation in a mammal by administering an immuno-suppressive amount of a compound having the structure



20

wherein R¹, R², and R³ are each, independently, hydrogen, or R⁴;

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R^4 is $-\left[C(CH_2)_mCH(CH_2)_nN\right]_pCO_2R^7$, $-\overset{\text{O}}{\overset{||}{\text{C}}}-\left(CH_2\right)_tX\left(CH_2\right)_uCO_2R^{11}$, or

$\begin{array}{c} \text{O} \\ \parallel \\ -\overset{\text{C}}{\overset{\text{||}}{\underset{\text{Y}}{\text{C}}}}-\text{CO}_2R^{12}; \end{array}$

R^5 is hydrogen, alkyl of 1-6 carbon atoms, aralkyl of 7-10 carbon atoms,

5 $-\left(CH_2\right)_qCO_2R^8$, $-\left(CH_2\right)_tNR^9CO_2R^{10}$, carbamylalkyl of 2-3 carbon atoms, aminoalkyl of 1-4 carbon atoms, hydroxyalkyl of 1-4 carbon atoms, guanylalkyl of 2-4 carbon atoms, mercaptoalkyl of 1-4 carbon atoms, alkylthioalkyl of 2-6 carbon atoms, indolymethyl, hydroxyphenylmethyl, imidazoylmethyl or phenyl which is optionally mono-, di-, or tri-substituted
10 with a substituent selected from alkyl of 1-6 carbon atoms, alkoxy of 1-6 carbon atoms, hydroxy, cyano, halo, nitro, carbalkoxy of 2-7 carbon atoms, trifluoromethyl, amino, or a carboxylic acid;

R^6 and R^9 are each, independently, hydrogen, alkyl of 1-6 carbon atoms, or aralkyl of 7-10 carbon atoms;

15 R^7 , R^8 , and R^{10} are each, independently, alkyl of 1-6 carbon atoms, aralkyl of 7-10 carbon atoms, fluorenylmethyl, or phenyl which is optionally mono-, di-, or tri-substituted with a substituent selected from alkyl of 1-6 carbon atoms, alkoxy of 1-6 carbon atoms, hydroxy, cyano, halo, nitro, carbalkoxy of 2-7 carbon atoms, trifluoromethyl, amino, or a carboxylic acid;

20 R^{11} and R^{12} are each, independently, alkyl of 1-6 carbon atoms, aralkyl of 7-10 carbon atoms, or phenyl which is optionally mono-, di-, or tri-substituted with a substituent selected from alkyl of 1-6 carbon atoms, alkoxy of 1-6 carbon atoms, hydroxy, cyano, halo, nitro, carbalkoxy of 2-7 carbon atoms, trifluoromethyl, amino, or a carboxylic acid;

25

X is $\begin{array}{c} \text{R}^{13} \\ | \\ -\overset{\text{C}}{\overset{\text{||}}{\underset{\text{R}^{14}}{\text{C}}}}-\text{O}, \text{ or S}; \end{array}$

R^{13} and R^{14} are each, independently, hydrogen or alkyl of 1-6 carbon atoms;

Y is CH or N;

30 m is 0 - 4;

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n is 0 - 4;
 p is 1 - 2;
 q is 0 - 4;
 r is 0 - 4;
 5 t is 0 - 4;
 u is 0 - 4;

wherein R^5 , R^6 , m, and n are independent in each of the $[C(CH_2)_m CH(CH_2)_n N]$

$$\begin{array}{c} O \\ || \\ -[C(CH_2)_m CH(CH_2)_n N]_p CO_2 R^7 \end{array}$$

$$\begin{array}{c} | \\ R^5 \\ | \\ R^6 \end{array}$$

subunits when p = 2;

or a pharmaceutically acceptable salt thereof, with the proviso that R^1 , R^2 , and R^3 are not all hydrogen, further provided that R^1 , R^2 , and R^3 are not all

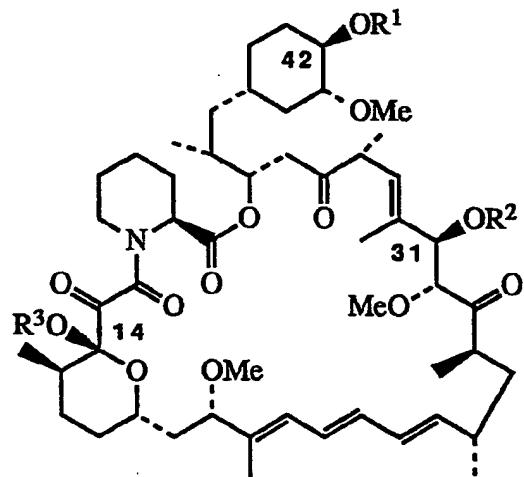
10

$$\begin{array}{c} O \\ || \\ -[C(CH_2)_m CH(CH_2)_n N]_p CO_2 R^7 \end{array}$$
, and still further provided that t and u are not

$$\begin{array}{c} | \\ R^5 \\ | \\ R^6 \end{array}$$

both 0 when X is O or S.

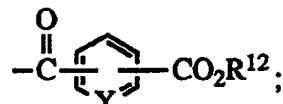
34. A method of treating fungal infections which comprises administering an
 15 antifungal amount of a compound having the structure



wherein R^1 , R^2 , and R^3 are each, independently, hydrogen, or R^4 ;

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R^4 is $-\overset{\text{O}}{\overset{||}{\text{C}}}[\text{C}(\text{CH}_2)_m\text{CH}(\text{CH}_2)_n\text{N}]_p\text{CO}_2\text{R}^7$, $-\overset{\text{O}}{\overset{||}{\text{C}}}-(\text{CH}_2)_t\text{X}(\text{CH}_2)_u\text{CO}_2\text{R}^{11}$, or



5 R^5 is hydrogen, alkyl of 1-6 carbon atoms, aralkyl of 7-10 carbon atoms, $-(\text{CH}_2)_q\text{CO}_2\text{R}^8$, $-(\text{CH}_2)_r\text{NR}^9\text{CO}_2\text{R}^{10}$, carbamylalkyl of 2-3 carbon atoms, aminoalkyl of 1-4 carbon atoms, hydroxyalkyl of 1-4 carbon atoms, guanylalkyl of 2-4 carbon atoms, mercaptoalkyl of 1-4 carbon atoms, alkylthioalkyl of 2-6 carbon atoms, indolylmethyl, hydroxyphenylmethyl, imidazoylmethyl or phenyl which is optionally mono-, di-, or tri-substituted with a substituent selected from alkyl of 1-6 carbon atoms, alkoxy of 1-6 carbon atoms, hydroxy, cyano, halo, nitro, carbalkoxy of 2-7 carbon atoms, trifluoromethyl, amino, or a carboxylic acid;

10 R^6 and R^9 are each, independently, hydrogen, alkyl of 1-6 carbon atoms, or aralkyl of 7-10 carbon atoms;

15 R^7 , R^8 , and R^{10} are each, independently, alkyl of 1-6 carbon atoms, aralkyl of 7-10 carbon atoms, fluorenylmethyl, or phenyl which is optionally mono-, di-, or tri-substituted with a substituent selected from alkyl of 1-6 carbon atoms, alkoxy of 1-6 carbon atoms, hydroxy, cyano, halo, nitro, carbalkoxy of 2-7 carbon atoms, trifluoromethyl, amino, or a carboxylic acid;

20 R^{11} and R^{12} are each, independently, alkyl of 1-6 carbon atoms, aralkyl of 7-10 carbon atoms, or phenyl which is optionally mono-, di-, or tri-substituted with a substituent selected from alkyl of 1-6 carbon atoms, alkoxy of 1-6 carbon atoms, hydroxy, cyano, halo, nitro, carbalkoxy of 2-7 carbon atoms, trifluoromethyl, amino, or a carboxylic acid;

25

X is $-\overset{\text{R}^{13}}{\overset{\text{C}}{\overset{\text{I}}{\text{C}}}}-$, O , or S ;

 R^{14}

30 R^{13} and R^{14} are each, independently, hydrogen or alkyl of 1-6 carbon atoms;

Y is CH or N ;

- 40 -

m is 0 - 4;

n is 0 - 4;

p is 1 - 2;

q is 0 - 4;

5 r is 0 - 4;

t is 0 - 4;

u is 0 - 4;

wherein R⁵, R⁶, m, and n are independent in each of the $[C(CH_2)_m CH(CH_2)_n N]$

$$\begin{array}{c} O \\ || \\ [C(CH_2)_m CH(CH_2)_n N]_p CO_2 R^7 \end{array}$$

$$\begin{array}{c} | \\ R^5 \\ | \\ R^6 \end{array}$$

subunits when p = 2;

or a pharmaceutically acceptable salt thereof, with the proviso that R¹, R², and R³ are
10 not all hydrogen, further provided that R¹, R², and R³ are not all

$$\begin{array}{c} O \\ || \\ - [C(CH_2)_m CH(CH_2)_n N]_p CO_2 R^7 \end{array}$$
, and still further provided that t and u are not

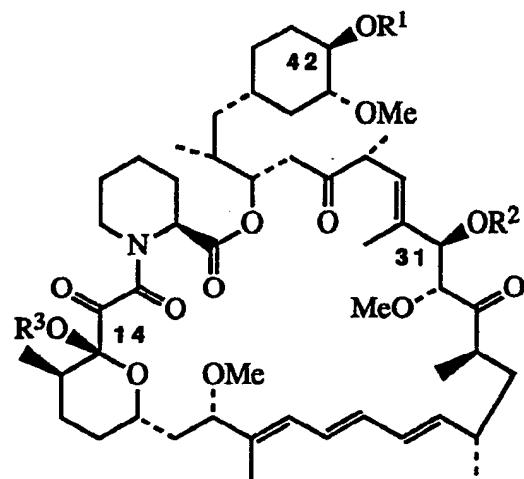
$$\begin{array}{c} | \\ R^5 \\ | \\ R^6 \end{array}$$

both 0 when X is O or S.

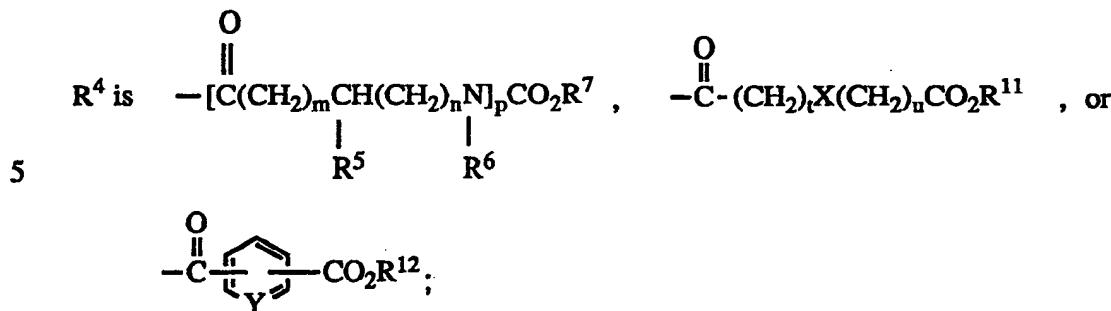
15

35. A pharmaceutical composition for the use in treating transplantation rejection, host vs. graft disease, autoimmune diseases, and diseases of inflammation in a mammal which comprises, an immunosuppressive amount of a compound having the structure

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wherein R¹, R², and R³ are each, independently, hydrogen, or R⁴;



R⁵ is hydrogen, alkyl of 1-6 carbon atoms, aralkyl of 7-10 carbon atoms,

10 -(CH₂)_qCO₂R⁸, -(CH₂)_rNR⁹CO₂R¹⁰, carbamylalkyl of 2-3 carbon atoms, aminoalkyl of 1-4 carbon atoms, hydroxyalkyl of 1-4 carbon atoms, guanylalkyl of 2-4 carbon atoms, mercaptoalkyl of 1-4 carbon atoms, alkylthioalkyl of 2-6 carbon atoms, indolylmethyl, hydroxyphenylmethyl, imidazoylmethyl or phenyl which is optionally mono-, di-, or tri-substituted with a substituent selected from alkyl of 1-6 carbon atoms, alkoxy of 1-6 carbon atoms, hydroxy, cyano, halo, nitro, carbalkoxy of 2-7 carbon atoms, trifluoromethyl, amino, or a carboxylic acid;

15 R⁶ and R⁹ are each, independently, hydrogen, alkyl of 1-6 carbon atoms, or aralkyl of 7-10 carbon atoms;

20 R⁷, R⁸, and R¹⁰ are each, independently, alkyl of 1-6 carbon atoms, aralkyl of 7-10 carbon atoms, fluorenylmethyl, or phenyl which is optionally mono-, di-, or tri-substituted with a substituent selected from alkyl of 1-6 carbon atoms, alkoxy

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of 1-6 carbon atoms, hydroxy, cyano, halo, nitro, carbalkoxy of 2-7 carbon atoms, trifluoromethyl, amino, or a carboxylic acid;

5 R¹¹ and R¹² are each, independently, alkyl of 1-6 carbon atoms, aralkyl of 7-10 carbon atoms, or phenyl which is optionally mono-, di-, or tri-substituted with a substituent selected from alkyl of 1-6 carbon atoms, alkoxy of 1-6 carbon atoms, hydroxy, cyano, halo, nitro, carbalkoxy of 2-7 carbon atoms, trifluoromethyl, amino, or a carboxylic acid;

10 X is $\begin{array}{c} R^{13} \\ | \\ -C- \\ | \\ R^{14} \end{array}$, O, or S;

10 R¹³ and R¹⁴ are each, independently, hydrogen or alkyl of 1-6 carbon atoms;

Y is CH or N;

m is 0 - 4;

n is 0 - 4;

15 p is 1 - 2;

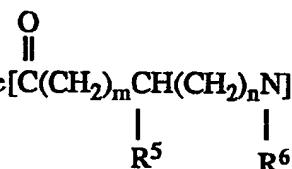
q is 0 - 4;

r is 0 - 4;

t is 0 - 4;

u is 0 - 4;

20 wherein R⁵, R⁶, m, and n are independent in each of the $[C(CH_2)_mCH(CH_2)_nN]$



subunits when p = 2;

or a pharmaceutically acceptable salt thereof, with the proviso that R¹, R², and R³ are not all hydrogen, further provided that R¹, R², and R³ are not all

25 $-\begin{array}{c} O \\ || \\ | \quad | \\ [C(CH_2)_mCH(CH_2)_nN]_pCO_2R^7 \end{array}$, and still further provided that t and u are not

both 0 when X is O or S.